THURSDAY, MAY 26, 1887.

TREATMENT AND UTILISATION OF SEWAGE.

Treatment and Utilisation of Sewage. By W. H. Corfield, M.A., M.D. (Oxon.). Third Edition, Revised and Enlarged by the Author and Louis C. Parkes, M.D., Cert. Public Health (Lond.). (London: Macmillan and Co., 1887.)

OF late years, discussions about sewage have occupied a large share of the proceedings of many of the Societies concerned with the practical application of science, and recent scientific discoveries have as yet done little to modify the conclusions of the last ten or fifteen years. Dr. Farr's Report on Vital Statistics proves that increased density of population (if sanitary conditions remain constant) is itself a cause of increased ill-health and death, which can only be counteracted by increased precaution. And the prominent position occupied by England in sanitation must be ascribed to the constant efforts which have been made to cope with the increasing density of the population. A danger to health arises from density of population mainly because of the retention in our midst of the impurities which are the necessary accompaniments of the act of living, that is to say, the retention of those substances which putrefy, and from the products of the putrefaction of which various matters, or, it may be, organisms, inimical to life, become disseminated through the air.

The new, a third, edition of Dr. Corfield's record of the treatment and utilisation of sewage is a valuable contribution to the history of the development of the methods by which some of these evils have been counteracted. The first edition was the practical outcome of researches and experiments made by a Committee of the British Association, which was appointed to consider the evils arising from the unsystematic arrangements which prevailed at the inception of the water-carriage system for sewage. Before the introduction of the water-carriage system, refuse polluted the soil under and around the houses, the wells, and the air: when water-carriage was resorted to, it was thought sufficient to allow the dirtied water to flow to the nearest outfall, and the result was the pollution of our ditches, streams, rivers, and seashores. Our experience of the way in which these evils can be overcome has been gained slowly and tentatively; and Dr. Corfield's record of the various processes which have been tried and abandoned is not only useful as a means of preventing those methods that have been found unsuccessful from being brought forward again, but the account he gives of the causes of failure teaches important lessons to the sanitarian—lessons that may enable him to combat the insanitary conditions which a dense population is continually developing under new and unforeseen aspects.

Much as the subject of sewage disposal has been discussed, the varying conditions under which towns have to dispose of their sewage make it impossible that there should be any uniform method of disposal. It is abundantly certain that sewage contains elements of value. Dr. Tidy values the sewage at 8*s*. or 9*s*. per annum per head of the population, of which the solid part is worth 1*s*. 2*d*. Dr. Corfield estimates the sewage of London alone at between £1,000,000 and £1,500,000. Dr. Liebig estimated it at £4,000,000. But Dr. Hoffman, in 1857, summed up this question in the statement that the value in London sewage was like the gold in the sands of the Rhine—it amounted to millions, but it would not repay the cost of recovering it. Some of our first authorities on the subject, indeed, having most strongly advocated the commercial value of sewage, have ended, after years of labour, by saying, "Get rid of it in the cheapest manner; throw it into the sea if you can." The assumption that, because sewage has within it manurial value, therefore its removal ought to produce a profit, has had a most unfortunate effect on the treatment of this question. The search after the philosopher's stone of profit in sewage-disposal retarded the sanitary movement for years.

But, whilst it is easy to say, "Throw your sewage into the sea," it is rarely that we can so deal with it without injuring foreshores or tidal estuaries, and many seaside resorts are suffering from such a method of disposal. A tidal river can only be safely resorted to under exceptional conditions. The discharge of crude sewage into a river, or, for the matter of that, on to land, is not satisfactory. For instance, the metropolitan sewage is poured into the tidal estuary of the Thames, where there is an enormous volume of water. Notwithstanding the purifying power of water, the sewage has seriously polluted the river beyond its capacity for purification in dry weather. On the other hand, it has been shown that the Barking and Halfway Reaches of the Thames, where the sewage is poured in, are really now better for navigation than they were before the metropolitan drainage outfalls were opened.

Independently, however, of the evils of the pollution of the tidal estuary of the Thames by the metropolitan sewage, we cannot conceal from ourselves that if some method of utilisation were feasible, even though it cost as much as we now pay for disposing of the sewage without utilisation, the resulting agricultural produce would be a gain to the nation. But there is not at present any generally-accepted plan for converting the metropolitan sewage into food, nor does it seem very probable that any method of treating the London sewage as a combined whole will enable us to do so usefully. The Metropolitan Board of Works, indeed, appear to consider it more prudent to submit to the known cost of loss than to embark on the more speculative course of endeavouring to rescue the valuable contents.

The most important question for the nation at the present time relates to other towns in the kingdom—that is to say, the question how, in the case especially of inland towns, can the sewage be purified so as to prevent it from damaging neighbouring properties, and make it fit to be passed into rivers. The best authorities are agreed on one point, viz. that it must not be sent crude into the rivers; and the preliminary straining off of the suspended matters is only a little less objectionable. Precipitation alone will not render the effluent water sufficiently pure; but if you let that effluent, after precipitation, flow over a small area of land, you will give the effluent the finishing touches towards

purification. Precipitation by chemicals implies certain conditions. First, if you want to treat sewage properly by a precipitation process, you must treat it fresh, before active putrefaction sets in. Secondly, before you mix your chemicals with it, you should strain the sewage in some way or other. Thirdly, you should add sufficient chemicals to effect complete purification. Fourthly, there should be efficient stirring after the addition of the chemicals. Fifthly, it is essential that you should have sufficient tank accommodation, for two reasons: first, that the precipitate may subside perfectly; secondly, that the sludge may be frequently removed. If you allow the old sludge to remain in the tanks, it is perfectly certain that it will contaminate the fresh sewage when it comes in. When the sludge is taken out of the tank, the tank itself must be washed. By combining precipitation, which will produce a good effluent, with land treatment or prepared filters, you may produce the best effluent that is known.

Intermittent downward filtration through land will adequately purify sewage so as to allow the effluent to pass into a stream; but by this plan the manure which is so much wanted is almost entirely lost, the greater part escaping in solution in the effluent water in the form of nitrates and nitrites. On the other hand, if the effluent is used for irrigation farming, under necessary conditions of soil and methods of application, the sewage is purified, a certain agricultural return is obtained, and, provided the irrigated land is placed at a sufficient distance (say 500 yards) from houses, the health and comfort of the neighbourhood are not endangered.

Dr. Corfield thus sums up his conclusions:—

"Wherever it is possible, irrigation should be carried out, the sewage having been previously freed, by one or other of the methods described, from the offensive suspended matters, which must be deodorised to prevent the production of a serious nuisance. Wherever, on the other hand, irrigation is practically impossible, intermittent downward filtration through soil affords the means of satisfactorily purifying the sewage."

Drs. Corfield and Parkes say that these were the conclusions at which they arrived seventeen years ago, and that they see no reason to alter them now; but we much doubt whether finality on this question of sewage-disposal has been arrived at. The cremation of refuse on a systematic plan is of only a few years' standing, and at present of somewhat limited application. Moreover, we stand on the threshold of discoveries as to the more occult causes of infection: we are learning daily much of the history and habits of those lower forms of life which play so large a part in putrefactive changes, and which are in some cases proved to be baneful to us under the conditions in which they now occur, but whose action we might possibly learn to modify under enlarged knowledge. We have recently seen how the extraction of oxygen from the atmosphere has risen from being a toy to the position of a practical art. These discoveries may eventually have some bearing on the safe disposal of the refuse matter which is continually being formed in the midst of dense populations. During the last twenty years we have made rapid strides in the methods of removal and disposal of refuse, which have been the result of the free development of the intelligence of the community in sanitary matters: each of those years has marked some step of progress, and we continue daily to advance. It is therefore to be hoped that Parliament will not accept the views of those persons who seem now to be endeavouring to stereotype by Act of Parliament our present position in sanitation, as if it were perfection. Such a step might seriously check future progress.

THE POLYZOA OF THE "CHALLENGER" EXPEDITION.

The Zoology of the Voyage of H.M.S. "Challenger." Part XXX. "Report on the Polyzoa—Part II. The Cyclostomata, Ctenostomata, and Pedicellinea." By George Busk, F.R.S., &c. (Published by Order of Her Majesty's Government, 1886.)

THE first and second memoirs contained in Vol. XVII. of the Zoological Reports of the Voyage of the *Challenger* were reviewed in NATURE two weeks ago (p. 26). The third memoir, the subject of the present notice, formed the last piece of scientific work of the distinguished naturalist to whom the preparation of the Report on the Polyzoa had been intrusted. During a period of illness and suffering under which the energies of most men would have broken down, Mr. Busk still laboured to accomplish the task which he had undertaken, and it was only a few days before his death that he was enabled to bring it to a conclusion.

The author deemed it advisable to divide the Report on the Polyzoa collected during the great exploratory voyage into two parts. The first of these has already been reviewed in NATURE (vol. xxxi. p. 146). It is confined to the Cheilostomatous species, and includes by far the greater number of all the Polyzoa collected. There still remained for consideration such species as are referable to the three remaining sections, namely, the Cyclostomata, the Ctenostomata, and the Pedicellinea. Each of these three groups has its representatives in the present Part, but the number of these is small in comparison with those referable to the Cheilostomata, and there does not occur among them any generic form which can be regarded as new. The account of them here given, while it completes the Report on the Polyzoa collected during the expedition, is characterized by all that careful and exact work which invariably marked the scientific labours of its author.

The entire number of species included in the present Part is forty-six, of which thirteen are now described for the first time. Of these forty-six species the most interesting are probably the two referable to the section Pedicellinea, and placed by the author in his genus Ascopodaria. The Pedicellinea form a very aberrant group of Polyzoa, presenting characters which differ widely from those met with in typical Polyzoal structure. They are represented in our own seas by two or three species of the curious genus Pedicellina, with its naked pedunculated polypides destitute of the "cells" into which the polypides of other Polyzoa admit of being retracted. The genus Ascopodaria is rendered further remarkable by the flask-like dilatation with muscular walls which exists at the origin of each peduncle. The

structure of this form is worked out in the Report with great care, and is illustrated by excellent figures depicting for the first time the anatomy of the genus as far as spirit specimens would admit of its demonstration.

The Report enters fully into the geographical and bathymetrical distribution of the species included in it. Of these the Cyclostomata attain the greatest depth, though only two of them extend to depths greater than 1000 fathoms; namely, *Crisia elongata*, which was obtained in the Australian region from a depth of 1450 fathoms, and *Idmonea marionensis*, which was brought up from a depth of 1600 fathoms in the region of Kerguelen Land. It is a fact, however, by no means without significance, as showing how little certain marine organisms of even complex structure are dependent on depth, that in the case of the last-mentioned species specimens have been obtained from depths varying from 50 fathoms downwards. The Ctenostomata and Pedicellinea are all from comparatively shallow water, none having been obtained from a depth greater than 150 fathoms.

No one could have been found better qualified than Mr. Busk to institute a comparison between recent and fossil Polyzoa. His work on the Polyzoa of the Crag is among the most important contributions we possess to the palæontology of this group, and gives a special value to his determination of the fossil relations of the species collected by the *Challenger*.

To the sub-order Cyclostomata belong the oldest fossil Polyzoa as yet known, and out of the thirty-three species of Cyclostomata obtained by the *Challenger* Mr. Busk has been able to identify fourteen as occurring also in a fossil state, thus proving the wide distribution in time of even specific forms of this group. No fossil species has as yet been identified with either the Ctenostomata or the Pedicellinea. The negative evidence, however, which is all that this statement expresses, proves but little, as these groups are destitute of structures which might be expected to continue recognizable in a fossil state. Barrois, indeed, contends that the larval stage of the Entoprocta (Pedicellinea) represents the primitive form from which the whole of the Polyzoa have descended. Of the Cheilostomata—the sub-order to which the former part of the Report is confined—no species has as yet been proved to belong to Palæozoic times, though this group is largely represented in Mesozoic and Tertiary strata.

The ten beautiful plates which illustrate this part of the Report contain figures of all the newly-described species of Cyclostomatous, Ctenostomatous, and Pedicellinean Polyzoa, and bear ample evidence to the conscientiousness and accuracy with which all the details of form are delineated.

The purely descriptive part of the Report is marked by all that judicious selection of characters, and succinctness yet definiteness of diagnosis, which add so much to the facility of comparison and to the practical value of any work having for its object the determination and description of specific forms. The number and variety of the species and generic types described and figured in this and the former part of the Report give to the whole a special value, not only as a record of the species collected, but as a faithful and comprehensive picture of the external morphology of the important and interesting group of organisms to which it is devoted. G. J. A.

OUR BOOK SHELF.

Dynamics for Beginners. By the Rev. J. B. Lock, M.A. Pp. 178. (London: Macmillan and Co., 1887.)

THIS book is an attempt to explain the elementary principles of dynamics in a manner suitable for school-work with boys of ordinary mathematical attainments. Accordingly it contains a great number of easy *numerical* examples, some worked out in illustration of the text, the others arranged in groups at frequent intervals. There is considerable freshness in these exercises, and they form altogether a very useful series.

The work is divided into four sections. The first treats exclusively of rectilinear dynamics, thus avoiding at the beginning of the subject all purely geometrical difficulties.

The second section introduces the notion of directed or vector quantities, and deals with the application of the parallelogram law to displacements, velocities, accelerations, and forces in succession.

Next we have a section on applications of the preceding to projectiles, oblique impact, circular motion, and relative motion, concluding with a short chapter on the hodograph.

The final section deals with energy, work, and power. These last three or four chapters read in connexion with the first section would form a suitable first course in many cases, involving no mathematics beyond a knowledge of simple equations in algebra.

The exposition throughout is remarkable for clearness and precision of statement. The definitions of terms seem particularly well worded. The names *velo* and *celo* have been adopted for the units of velocity and acceleration, and are used systematically in both text and examples; we hope these terms may win their way to general acceptance, for the language of the subject gains both in simplicity and directness by their introduction.

The debt of gratitude which many teachers and students already owe to Mr. Lock will be considerably increased by this new class-book on a difficult subject, wherein it appears to us that the skill and experience of the author are displayed with great advantage.

Journals kept in Hyderabad, Kashmir, Sikkim, and Nepal. By Sir Richard Temple, Bart., M.P. Edited, with Introductions, by his son, Richard Carnac Temple. With Maps and Illustrations. Two Vols. (London: W. H. Allen and Co., 1887.)

THE first journal contained in these volumes was written at Hyderabad during the year 1867, when the author was Political Resident at the Court of the Nizám. It is entirely political, and will interest only those who study somewhat minutely the course of recent Anglo-Indian history. The journals kept during visits to Kashmir, Sikkim, and Nepal appeal to a larger class of readers. They deal with the physical features of these countries, and to some extent with social customs and institutions. Most of the author's notes are too slight to be of much scientific importance; but all of them have the merit of being written in a clear and unpretending style, and the information contained in them is, so far as it goes, thoroughly trustworthy. The introductions which the editor has contributed to the book add very considerably to its value. They are careful essays, in which Capt. Temple has brought together a great many interesting and suggestive facts that are not readily accessible to ordinary readers.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Sunlight Colours.

WILL you permit me to say, in relation to the very interesting lecture on Sunlight Colours, reported in NATURE, vol. xxxv. p. 498, that Capt. Abney does not seem to have quite apprehended my meaning, when he represents me as stating in a previous lecture at the Royal Institution, that the sun was "really blue outside our atmosphere," for I nowhere in the lecture used those words, nor intended to convey the idea which, without qualification, they must give the reader.

I recognize, however, that if my actual words conveyed it to so fair-minded a critic as Capt. Abney, they must have been open to misconstruction, and I therefore ask permission to recall in explanation an important fact referred to in the lecture, to which he does not allude. It is that the sun is surrounded by an atmosphere of its own, and that the prime modification of its actual colour at the photosphere takes place *there*. Only the secondary change of colour takes place in the earth's atmosphere. "Outside our atmosphere," accordingly, we see, not the absolute colour of the photosphere, but one already greatly modified toward white. I meant, then, when formally defining the colour of the sun outside our atmosphere, to use such qualified phrases as "tends toward blue," or "bluish," and it was for the colour of the sun itself, *i.e.* at the photosphere, and before any absorption, that I meant to reserve the word "blue." Let me hasten to add that I also tried—even to iteration—to insist that "blue" here does not and cannot mean a monochromatic blue, but a combination of all the spectral colours, in which those of the blue end appear in such immense predominance that this is the dominant effect.

Capt. Abney also says: "he" (I) "surmised the result from experiments made with rotating disks of coloured paper. He did not, I think, try the method of using pure colours."

Capt. Abney will, I think, agree on consideration that these words may be liable to convey to most readers a wrong impression of labours which began nearly fifteen years ago, with studies on the absorption of the sun's atmosphere, resting on direct and elaborate photometric comparisons of the light of its centre and edge. These have been followed by confirmatory measures with the bolometer, giving the relative proportions of the pure colours in the normal spectrum, and the tint has not been surmised, but experimentally shown by the actual combination of pure spectral colours.

The solar studies were supplemented in the four years preceding my lecture by almost unintermittent investigations on the absorption of the earth's atmosphere, in which (though considerably over 20,000 galvanometer readings were recorded) I do not recall ever making any observation by the aid of "rotating disks of coloured paper." The paper disks have been often employed in explanation of my method, to roughly show the principles involved, and to *illustrate* results, but certainly not as means by which these results were surmised or discovered.

In a communication to the British Association, published in NATURE, vol. xxvi. p. 586, after alluding to the antecedent researches of Mr. Lockyer and others, which show that certain rays of short wave-length are more absorbed than those of long, I exhibited charts showing how much each ray had grown. One of these, which suffered some curtailment at the hands of the engraver to fit it to the height of the page, was reproduced in the report of the lecture (NATURE, vol. xxxii. p. 42), and it is possibly from this that Capt. Abney derives his impression as to my results in other respects. I can only conjecture that it may be so, since in my professional memoirs there are, not only more accurate charts, but with them warnings that the figures representing the relation of the blue and red end in such drawings, or even in the tables whence they are taken, necessarily give minimum values of the blue.

The fact that this blueness was first predicated from a long and careful study of the absorption of the sun's atmosphere is a distinct one, and I am entirely disposed to admit that this point was not explained at sufficient length in my lecture, in which I had but an hour to describe the work of twelve years. Being forced to confine myself to an account of some limited portion of this long research, I chose that part of it which dealt with the absorption of the earth's atmosphere, as illustrated by the expedition to Mount Whitney, but I thought the facts just stated about the influence of the sun's atmosphere too important to go without explanation altogether, and rehearsed them substantially in other words before entering at length on the subject of the telluric absorption.

As the observations on the sun's atmosphere are still unpublished, it may be of interest if I give here, in anticipation of the final reductions, the approximate results of some made at Allegheny in 1882, and which were supplemented by others which I was enabled to make at South Kensington in the same year by the kindness of Mr. Lockyer.

This table gives the reduction to the normal spectrum at the points indicated in the first line, where λ designates the wavelength and μ = one micron = 1/1000 of one millimetre. The second line gives the approximate transmission by the solar atmosphere (not alluded to in Capt. Abney's lecture). The third line gives the approximate transmission by the earth's atmosphere alone (numbers nearly concordant with those he seems to employ for this secondary effect); and the fourth, the combined effect of the two. It is from such numbers as those in this fourth line that we have deduced the true colour of the sun at Allegheny, by methods to be presently alluded to, and which authorize us to state that its dominant tint before any absorption is not so much "bluish" as "blue."

	μ 0·40	μ 0·45	μ 0·50	μ 0·55	μ 0·60	μ 0·65	μ 0·70	μ 0·75
Transmission by solar atmosphere	·16	·24	·30	·35	·38	·41	·43	·45
Transmission by terrestrial	·31	·44	·53	·61	·68	·74	·79	·83
Resultant transmission by both atmospheres	·05	·11	·16	·21	·26	·30	·34	·37
Reciprocal of last, showing approximate brightness before any absorption...............	20·2	9·5	6·3	4·7	3·9	3·3	2·9	2·7

Thus we see that of the extreme blue or violet light, whose wave-length is 0·4μ, 16 per cent. (*i.e.* less than $\frac{1}{6}$) only is transmitted by the solar atmosphere, and of this 16 per cent. 31 per cent. only is transmitted by the earth's atmosphere. It is of this latter alone that Capt. Abney here takes account, but in consequence of the absorption by both atmospheres, only about 5 per cent. of the original violet light reaches us; or in other words, before the double absorption there was over twenty times as much of this sort of blue in the sun as what we now see. On the other hand, of the deep red light whose wave-length is 0·75 μ as much as 45 per cent. is transmitted by the solar atmosphere, and of this again 83 per cent. by the earth's; so that after the action of both atmospheres on this ray 37 per cent. is transmitted as against 5 per cent. of the violet. If we take the reciprocal of the numbers in this fourth line we have those of the fifth, which evidently show the relative intensity of the colours at the photosphere (*i.e.* before any absorption), as compared with that of common daylight. I employed in 1882 an optical arrangement, suggested by Mr. Very of the Allegheny Observatory, by which we passed from these figures to the production of the actual resultant tint of the solar photosphere; not by using pigments or revolving disks, but by the direct combination of pure spectral colours in the above proportions. The resultant colour cannot, I repeat, be exactly defined by any one spectral one, as it was not monochromatic; but the tint was, to my eye and that of others, best technically defined as that of Herschel's lavender, with perhaps a suggestion of purple; and certainly I think now, as I thought then, that "blue" is the nearest familiar word to describe it.

It was with all these facts, and many more, in my possession, that I used the language in question.

I hope after this statement that I may conclude that Capt. Abney and I have really no serious ground of difference as to the propriety of the term "bluish," or as to what it here means. I would only say that by no latitude of interpretation do I take it as meaning *white*. S. P. LANGLEY.

Smithsonian Institution, Washington, D.C., May 2.

The Eclipse of August 19, 1887.

THIS eclipse will be seen over such an extent of territory that it is desirable to make the best use of the opportunity offered. The astronomical observations I do not mention, but besides them the following would be very important, and could be made by travellers alone, and those who do not take with them heavy and troublesome instruments:—

Observations every ten minutes on the *pressure* and *temperature* of the air from the beginning of the eclipse to about half an hour after its end; and, some days before and later, every hour, at the hours of the eclipse.

The *barometer* might as well be an aneroid, but with large divisions; a pocket instrument would be too small. Relative and not absolute measures are intended, and it is especially necessary that the instrument be not sluggish.

The *thermometer* preferable for the observations should be a sling-thermometer (Frowde), as one in a thermometer-stand and not swung could not follow rapidly enough the changes of temperature. It would be best to swing it at the height of the shoulder.

Observations on *cloud, direction* and *force of wind*, every half hour the day of the eclipse and every hour before and later.

Some observations on the colour of the sky, &c., and on the influence of the eclipse on animals, domestic and wild, would be useful.

The eclipse will be visible in Eastern Germany, but at so early an hour in the morning that there will be comparatively little interest in meteorological observations. Russia (especially Eastern) and Western and Central Siberia give much better opportunities of observation. I give below some notices on the amount of cloud; the stations are disposed from west to east, the mean is that of three observations, 7 a.m., 1 p.m., and 9 p.m. The conditions as to cloudiness will be better than those indicated here, in Eastern Russia and Siberia to nearly Lake Baikal, as the eclipse will be seen in the later morning hours, which have a smaller amount of cloud than 7 a.m. and 1 p.m.

Amount of Cloud.

	Mean	7 a.m.
Rjev, Government of Tver	57	49
Moscow	57	50
Academy of Petrovsky, near Moscow	51	
Rojdestwenskoye, Government of Kostroma	60	61
Kasan	58	55
Viatka	53	51
Ekaterinburg	68	67
Nijnetaguilsk	64	
Bogoslovsk	57	
Irbit	53	
		1 p.m.
Irbit		69
Yeniseisk	53	
Irkutsk	49	48
Foundry of Nertschinsk	53	59
Niigata, west coast of Nippon	55	

I give a list of some places where tolerably good accommodation is to be found, with the time of travel from the nearest railway-station:—

Tver, Torjok, Moscow,[1] Yaroslav,[2] Kostroma (three hours' steamer from latter point), Schuja, Ivanovo-Wosnessensk, Kineschma, Vladimir, Viatka (steamer on Volga, Kama, and Viatka, from Nijni-Novgorod, in three days), Perm (steamer from Nijni-Novgorod in eighty-five hours.

Nijnetaguilsk, with important foundries, malachite mines, &c., reached by railroad from Perm in fifteen hours.

Tobolsk, by rail from Perm to Tjumen in about thirty hours, thence by steamer in two days, twice a week. It is well to telegraph beforehand to retain a cabin.

Tomsk by steamer from Tjumen in about eight days, by the Tura, Tobol, Irtysch, and Ob.

The places eastward, the most favourable for observation, can be reached by road only from Tomsk. Post-horses everywhere available, rapid travelling in good weather, but bad carriages.

To astronomers bringing with them bulky instruments, the water-ways are to be recommended. St. Petersburg is in easy steamer communication with British harbours, and thence luggage can be sent by water to all parts of the Volga basin. So far as known at present, it is intended that there shall be observations of the eclipse at five points: (1) the observatory of General Maiewsky, Government of Tver; (2) the estate of Count Olsuffiew, district Dmitrov, Government of Moscow; (3) the estate of Prof. Bredichin, district Kineschma, Government of Kostroma,—two English astronomers are expected; (4) Glasov, Government of Viatka; (5) Krasnoiarsk, on the Yenisei.

A. WOEIKOF.

[1] Just at the southern limit, it would be better to observe somewhat to the north.

[2] See Mackenzie-Wallace's "Russia."

Iridescent Clouds.

THE clouds seen by Prof. Stone, as described in NATURE, vol. xxxv. p. 581, may have been of the same character (though I cannot judge positively from the description) as those so extensively observed in the Decembers of 1884 and 1885; if so, it is the only account I have read of their being seen last winter. Those described by Mr. McConnel, writing from St. Moritz, Switzerland (p. 533), are evidently of a totally different character, and I suppose simply the ordinary iridescent clouds which are common everywhere. T. W. BACKHOUSE.

Sunderland.

Remarkable Hailstones.

MAY I ask for space to make a suggestion as to the possible cause of the banded structure of hailstones recently observed and recorded in NATURE, vol. xxxv. p. 438? It seems to me that the phenomenon may perhaps be explained by *devitrification of the ice*. We are familiar with a considerable number of bodies which assume the vitreous state by rapid solidification from the liquid state; and it seems reasonable to suppose that in the conditions under which hail is formed the ice may assume at first the vitreous state, the higher molecular structure of perfectly crystalline ice requiring more time for its full development (see paper by the writer read before Section C of the British Association last year at Birmingham). If such were the case (and the hypothesis is supported by the statement of Mr. C. S. Middlemiss in NATURE, vol. xxxv. p. 413), the observed structure (which can be actually seen to develop itself in some vitreous substances under the microscope, as a preliminary to the assumption of the full crystalline and opaque condition) would simply mark an early stage of the devitrification of the ice-glass. To bring this theory to the test of experiment it would only be necessary to observe closely the effect of keeping such hailstones for some time at a temperature rather below 0° C. A. IRVING.

Wellington College, Berks, May 14.

The Orbit of the Minor Planet Eucharis.

ON reading your note (p. 16) on the determination of the orbit of the planet *Eucharis*, by Dr. de Ball, and the discordances between his observations and those obtained with the Washington meridian instrument, I am reminded of an earlier case which seems to me to be analogous.

Hansen drew attention to the very material difference between the observations of *Egeria* in 1864 at Bonn and Leyden. This discrepancy between observations which otherwise harmonized well amounted to 10″ in R.A., and occasioned a protracted inquiry by Argelander (*Astron. Nachr.*, No. 1769), in which he came to the conclusion that the reason probably lay in the personal error of the Leyden observer in the observation of bright and faint stars. As I am not acquainted with Dr. de Ball's treatise, I cannot judge whether respect was paid to such differences in isolated cases. W. VALENTINER.

Karlsruhe Observatory, May 8.

A Question for Chemists.

YOUR correspondent, Mr. West, will find reference to the fact that a mixture of glycerine and potassium permanganate is liable to spontaneous combustion in the "Extra Pharmacopœia" of Martindale and Westcott, fourth edition, p. 292.

Dublin. HARRY NAPIER DRAPER.

"A Junior Course of Practical Zoology."

IN a recent notice of "A Junior Course of Practical Zoology" (NATURE, vol. xxxv. p. 506) the reviewer expresses surprise

that anyone should, in a text-book for students, "discard the ophthalmic somite of their seniors, and press the telson into the service," a procedure on which he comments thus:—"The introduction of so sweeping a change into a book for juniors, without due comment is, under these circumstances, a false step, especially when it is considered that the precise converse is stated in all other books current."

Now Claus in his text-book says (I quote from the English edition):—"The facetted eyes are borne on two movably separated stalks. These were for a long time considered as the anterior pair of appendages, while in fact they are merely lateral portions of the head which have become jointed"; and elsewhere: "The last abdominal segment, which is transformed into a telson."

Gegenbauer in his text-book says:—"The projecting character of the eye, owing to its curvature, may lead to a stage in which the eye is stalked. When still more developed, this stalk may become movable"; and nowhere speaks of the stalk as the homologue of an appendage.

Prof. Lankester's pupils are all taught to regard the telson as a somite and the "ophthalmic somite" as an erroneous interpretation of parts.

I fail to see, therefore, that Prof. Marshall need offer any excuse for his method of counting the segments, nor, in an elementary text-book, discuss a question on both sides of which there is avowedly much to be said.

I may note with regard to one other criticism that, although there is nothing "irrelevant or absolutely fantastic" about the term commissure, it is convenient to distinguish between "commissures connecting two ganglia of the same pair" and "connectives connecting ganglia of dissimilar pairs" ("Encycl. Brit.," ed. ix. Art. "Mollusca"). The "word-mongerers" are here marking "a turning-point in advance."

Madras, April 20. A. G. BOURNE.

"On the Establishment of the Roman Dominion in South-East Britain."

IN my article on the above subject printed in NATURE, vol. xxxv. p. 562, I have briefly alluded to the ridiculous mutiny of the Roman soldiers. I ought to have added (from Dio) the relation of the following incident, which terminated the mutiny:—

"Taking courage, because a brilliant meteor rising in the east passed across to the west, to the part to which they were making their course, they descended on the island."

That is, the Romans descended from an easterly part of Europe upon Britain.

This agrees with the course which in my former letter I assigned as most probable; namely, that the Romans sailed from the mouth of the Scheldt to Southend. G. B. AIRY.

The White House, Greenwich, May 18.

FLORA OF CHRISTMAS ISLAND.

THE Hydrographer of the Admiralty has kindly forwarded to Kew, as he has stated in his note in NATURE for May 5, p. 12, the botanical specimens collected during the visit of H.M.S. *Flying-Fish* to Christmas Island. They were unfortunately, as explained by Capt. Maclear, a mere residue of the collection which was obtained. The examination of a better preserved and more extensive one would be interesting, as the flora is evidently of a less common-place kind than that generally met with in coral islands.

In all, twenty-four species admitted of approximate determination. Of these five were ferns, all widely-spread species. Of the remaining nineteen flowering plants five are also probably identical with widely-distributed species, and they occur in the Cocos or Keeling Islands between which and Java Christmas Island lies. The much more limited flora of these islands is only known from the collections of the late Mr. Darwin, and of Mr. H. O. Forbes. Of the remaining fourteen species at least six must be set aside, the specimens being too imperfect to be more than approximately determinable. Of the rest, two, a *Vitis* near *V. pedata*, Vahl, and an *Ehretia*, may, in Prof. Oliver's opinion, possibly be new; the teak (*Tectona grandis*, L. f.) occurs generally in the Malayan Archipelago; *Euphorbia Chamissonis* is interesting as a Polynesian type; fruits of *Barringtonia* are thrown up universally on shores in the Malayan waters; *Terminalia Catappa*, L., is found pretty well everywhere in the tropics; the remaining two suggest no special remark.

The collection unfortunately throws little light on the composition of the dense arborescent vegetation with which Capt. Maclear found it to be covered. Teak probably forms large trees. *Cordia subcordata*, Lam., which occurs also in the Cocos-Keeling Islands, and, according to Mr. H. O. Forbes, originally covered them abundantly,[1] is known there as "iron-wood," and is no doubt one of the iron-wood trees recognized by Capt. Maclear in Christmas Island. It is widely distributed throughout the Malayan Archipelago, and extends to the Philippines and some of the Pacific islands.[2]

On the whole, it can hardly be doubted that Christmas Island has been stocked with its flora by the agencies described by Dr. Guppy, and worked out by Mr. W. B. Hemsley in the "Botany Report of the Voyage of H.M.S. *Challenger*" (vol. i. part 3, p. 310): "Winds and currents drift to their shores the fruits and seeds of the littoral trees which ultimately form a belt, whilst the fruit-pigeons disgorge the seeds or fruits of those often colossal trees which occupy the interior."

The former agencies brought no doubt *Barringtonia*, *Hibiscus tiliaceus*, *Terminalia*, *Cordia subcordata*, *Ochrosia parviflora*, and *Pandanus*. Carpophagous birds are elsewhere known to bring a profusion of fruits of palms, nutmegs, *Euphorbiaceæ* and *Laurineæ*, and other arborescent species. Upon this element in the flora of Christmas Island the collection, as already remarked, throws insufficient light. The flora of Java is still but imperfectly known, and though there is no reason to believe that that of Christmas Island contains any absolutely endemic species, it would not be surprising if a careful examination yielded many plants new to science which have yet to be ascertained from the larger contiguous island, from which they have been derived.

W. T. THISELTON DYER.

THE JOURNAL OF THE ROYAL MICROSCOPICAL SOCIETY—RETROSPECTIVE AND PROSPECTIVE.

THE month of March 1878 will ever remain memorable in the annals of microscopy in this country, for it marked the regeneration of the Journal of the Royal Microscopical Society, the most conspicuous feature of which was the introduction, for the first time, of a systematic record of current researches under the title of "Notes and Memoranda." Now that the period of editorship which worked the change is fast approaching its decade, we would wish to review the position, in anticipation of the introduction of still further modifications which, it is to be assumed, the editors will adopt on entering upon a second period.

We read in the preface to the first volume that the "Notes and Memoranda" are intended to present a summary of what is doing throughout the world in all branches of microscopical research. Whilst extracts from English publications will not be excluded, preference will be given to those of foreign countries, as being less easily accessible. Amongst these will be included the Transactions and Proceedings of the Academies of the United

[1] "Naturalist's Wanderings in the Eastern Archipelago," pp. 28, 29.

[2] Mr. H. O. Forbes (*l.c.* pp. 26, 27) gives a curious account of the way in which the labours of a crab turn the white calcareous fore-shore of coral islands into "a dark vegetable mould." They do this by burying systematically particles of vegetable *débris*; by scooping away the soil beneath them they lower down even large branches of trees. The ground thus enriched is fitted for occupation by plants; and as Mr. Forbes particularly noticed that they carry "down also the newly-fallen seeds of the iron-wood" these industrious factors in the economy of a bare coral island not merely prepare the soil but also plant it.

States, France, Belgium, Germany, Austria, Italy, and Russia, together with the microscopical, botanical, and zoological journals of those countries. It will be obvious to anyone who will compare the last few numbers of the Journal with the first volume, from which we have just quoted, that the former are no less superior to it in general excellence than it was to its immediate predecessors. The editors have elaborated their scheme with the growth of the Journal, and have, in their desire to satisfy the public, gone beyond the prescribed limits, and incorporated abstracts of all the more important papers in certain branches of the science, whether microscopical or not.

In no period of the history of biological science has advance been so rapid as within the last decade, and it is no exaggeration to say that the Journal before us is a faithful historical record of the work done during that period, in those branches with which it professes to deal. To him who would labour in earnest at a given subject the original monographs are indispensable; but even the narrowest of specialists must obtain some knowledge of the advance made in cognate branches of his science, and a ready means of acquiring this, as it applies to microscopy, has been provided by the Journal named during the period of which we write.

It might naturally be supposed that the increase in native workers, whose labours have so far extended the literature of the science and consequently swelled the pages of the Journal in which that literature has been abstracted, must have resulted in a corresponding increase in the circulation of the Journal itself. This, we are informed, has not been the case. In reflecting upon this fact we must remember that during the past decade many changes have been wrought in the literature of biological science. Anzeigers and Records have been established and augmented. But withal the "Notes and Memoranda" of the Society's Journal have made a place for themselves in the library of the working biologist; the abstracts are up to date, and frequently fairly detailed, and they are invaluable to workers who, though not actual specialists, are so placed as to be beyond reach of a good reference library.

The Journal is primarily a microscopical one, and such it must continue to be under the Charter of the Society whose organ it is. Supplemental matters are added by courtesy; but we believe the editors would do well to restrict themselves to purely microscopical matters. In these days of profuse literature showered upon us from all parts of the globe, it is highly desirable that the aims and scope of all journals should be clearly defined and adhered to, if only by way of enabling the worker to know approximately where to turn in search of information upon a given subject. Much has been done of late in this direction by other Societies, and we submit the suggestion to the executive of the one whose Journal we are considering, in full assurance that in restricting their labours as indicated they will be still further contributing to the utility and success of their venture. We would also suggest that pains might occasionally be taken to set forth more fully than hitherto the precise vantage gained by authors quoted, to the exclusion of purely historical *résumés* and details of minor importance. The vital points of a paper are occasionally sacrificed to the reproducing of descriptions of insignificant structural details; and attention to this point would, we believe, enhance the value of the abstracts without in any way lengthening them. Further, work in the native tongue has not always received that attention which it merits.

The editorship of the Journal could not be in better hands than at present. Officers of the Society and all engaged have laboured indefatigably, and they deserve unstinted praise in the execution of their somewhat thankless task. Under the present editorship the Journal has attained a definite and responsible position, beyond that which it occupies as the organ of a chartered Society; its pages are quoted as authoritative records, and we would fain see it more widely disseminated than at present. It is pre-eminently a microscopical journal for workers; it stands unique in its combined features, and is second to none extant in its dealing with the *technique* and optics of the subject. If it is deemed worthy of the formulæ of Abbé, and of orginal articles by the President of the Royal Society, it is deserving of maintenance at the hands of English-speaking people.

BRIDGING THE FIRTH OF FORTH.[1]

DURING the past four years many thousands of visitors from all parts of the United Kingdom, and, indeed, I may say from all parts of the world, have more or less carefully inspected the works now in progress under the superintendence of Sir John Fowler, the engineer-in-chief, and myself, for bridging the Firth of Forth. All classes of visitors, whether possessed of technical knowledge or not, have found at least something to interest them amongst the multifarious operations incidental to carrying out so gigantic an undertaking; and I should have little fear of interesting my present audience if I could change the scene from Albemarle Street to the shores of the Forth. That is impossible, so I must rest content with an imperfect attempt to convey to you, by description and illustration, some notion of the magnitude of the proportions and difficulties of construction of what is generally admitted to be one of the most important engineering works yet undertaken. A "personally conducted" tour over the work would be far more congenial to me than giving a lecture, and infinitely more effective. Photographs, and even the highest efforts of pictorial art, are a poor substitute for the reality. The smallest street accident witnessed by ourselves affects us more than a description or picture of the greatest battle, and for similar reasons I well know that when I speak of men working with precarious foothold at dizzy heights in stormy weather my words will sound very different in this room to what they would were my listeners standing beside me in an open cage hanging by a single wire rope, in appearance like a packthread, and swinging more or less in the wind at a height of between three and four hundred feet above the ground; or were they following me up a ladder as high as the golden cross on the top of St. Paul's Cathedral, with the additional excitement of the rungs of the ladder being festooned with icicles a foot long. You will lose a great deal in vividness of impression necessarily by the substitution of a lecture for a personal visit to the works, but there are some compensating advantages, as you will be saved between eight and nine hundred miles of railway travelling, and a good deal of clambering of the kind shadowed forth.

I should not have thought it necessary to preface my remarks by the statement that the Forth Bridge has nothing to do with the Tay Bridge, had not my four years' experience informed me that about one-half of my fellow-countrymen labour under that singular hallucination. Even at this date I fully expect every second Britisher (of course Americans and foreigners are better informed) to say: "How are you getting on with the Tay Bridge?" I suggest "Forth Bridge," and the correction is generally accepted as a mere refinement of accuracy on my part. As a matter of fact, however, the Tay Bridge which was blown down in 1879, and has since been rebuilt, is at Dundee, whilst the Forth Bridge is near Edinburgh; and as regards type of construction there is nothing in common between the two. If my lecture serves no better purpose, it will at least help, therefore, to disseminate a little useful geographical knowledge respecting the Firths of Forth and Tay.

[1] Lecture delivered at the Royal Institution, on Friday, May 20, by B. Baker, M. Inst. C.E.

And yet the Forth which "bridled the wild Highlander," and especially that part of it where the bridge crosses, should be well enough known to every reader of fiction, for it has been made the scene of many adventures. Mr. Louis Stevenson's thrilling story, "Kidnapped," will have been read by most of you; the hero of that story was kidnapped at the very spot where the bridge crosses, so I can describe the point of crossing in David Balfour's own words:—

"The Firth of Forth (as is very well known) narrows at this point, which makes a convenient ferry going north, and turns the upper reach into a land-locked haven for all manner of ships. Right in the midst of the narrows lies an island with some ruins; on the south shore they have built a pier for the service of the ferry, and at the end of the pier, on the other side of the road, and backed against a pretty garden of holly-trees and hawthorns, I could see the building which they call the Hawes Inn."

Such was the appearance of the spot 150 years ago. The middle pier of our bridge now rests on the island referred to, and the Hawes Inn flourishes too well, for being in the middle of our works its attractions prove irresistible to a large proportion of our 3500 workmen. The accident ward adjoins the pretty garden with hawthorns, and many dead and injured men have been carried there, who would have escaped had it not been for the whisky of the Hawes Inn.

I would wish if possible now to convey to my hearers some clear impressions of the exceptional size of the Forth Bridge, for even those who have visited the works and noted the enormous gaps to be spanned on each side of Inch Garvie, may yet have gone away without realizing the magnitude of the Forth Bridge as compared with the largest railway bridges hitherto built. For the same reason that architects introduce human figures in their drawings to give a scale to the buildings, do we require something at Queensferry to enable visitors to appreciate the size of the Forth Bridge. If we could transport one of the tubes of the great Britannia Bridge from the Menai Straits to the Forth, we should find it would span little more than one-fourth of the space to be spanned by each of the great Forth Bridge girders. And yet it was of this Britannia Bridge that Stephenson, its engineer, thirty years ago said:—"Often at night I would lie tossing about, seeking sleep in vain. The tubes filled my head. I went to bed with them, and got up with them. In the gray of the morning, when I looked across Gloucester Square, it seemed an immense distance across to the houses on the opposite side. It was nearly the same length as the span of my tubular bridge!"

Our spans, as I have said, are each nearly four times as great as Stephenson's. To get an idea of their magnitude, stand in Piccadilly and look towards Buckingham Palace, and then consider that we have to span the entire distance across the Green Park, with a complicated steel structure weighing 15,000 tons, and to erect the same without the possibility of any intermediate pier or support. Consider also that our rail level will be as high above the sea as the top of the dome of the Albert Hall is above street level, and that the structure of our bridge will soar 200 feet yet above that level, or as high as the top of St. Paul's. The bridge would be a startling object indeed in a London landscape.

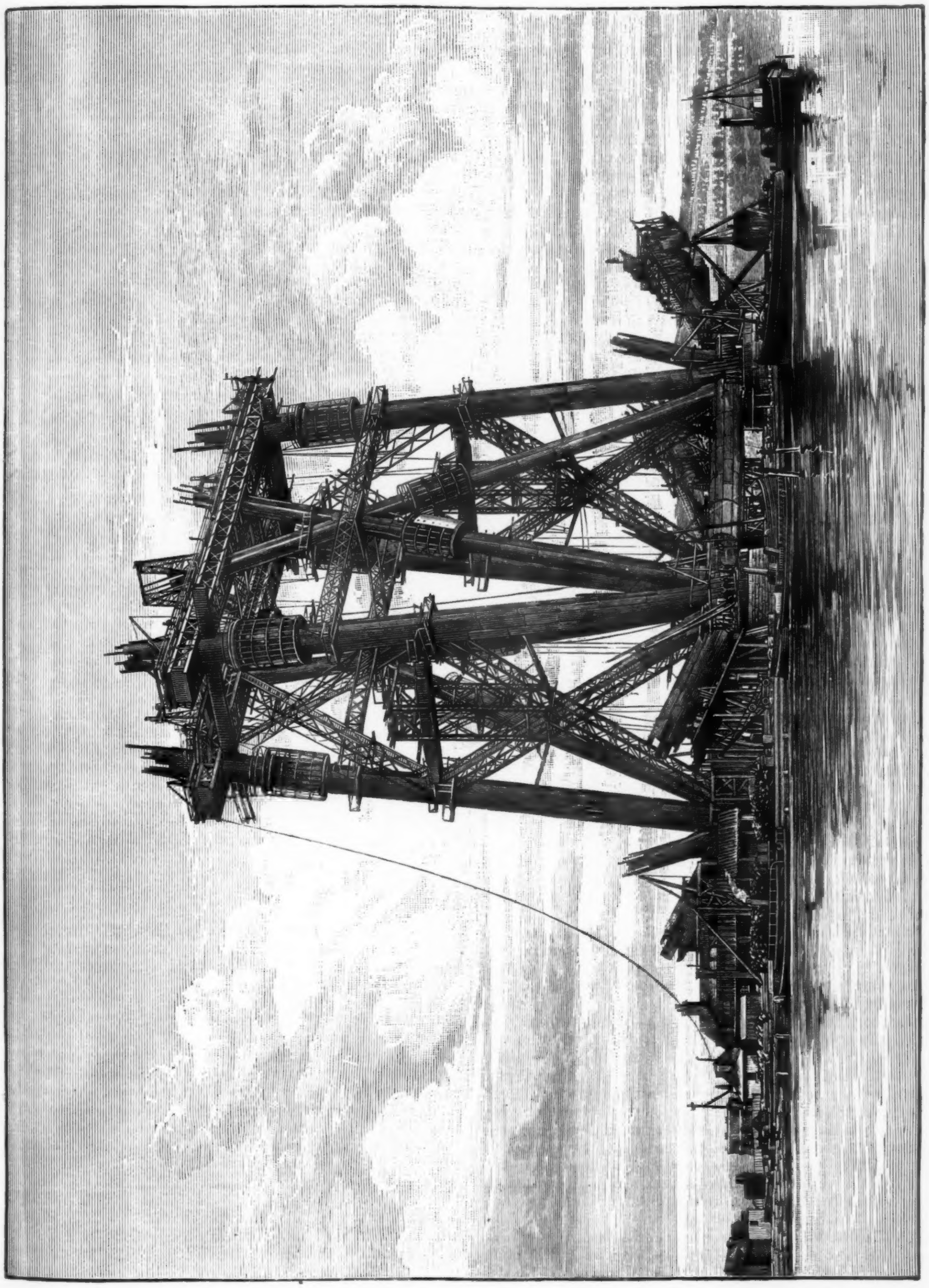
It is not on account of size only that the Forth Bridge has excited so much general interest, but also because it is of a previously little-known type. I will not say novel, for there is nothing new under the sun. It is a cantilever bridge. One of the first questions asked by the generality of visitors at the Forth is, Why do you call it a cantilever bridge? I admit that it is not a satisfactory name and that it only expresses half the truth, but it is not easy to find a short and satisfactory name for the type. A cantilever is simply another name for a bracket. The 1700-feet openings of the Forth are spanned by a compound structure consisting of two brackets or cantilevers and one central girder. Owing to the arched form of the under-side of the bridge, many persons hold the mistaken notion that the principle of construction is analogous to that of an arch. In preparing for this lecture the other day, I had to consider how best to make a general audience appreciate the true nature and direction of the stresses on the Forth Bridge, and after consultation with some of our engineers on the spot a living model of the structure was arranged as follows:—Two men sitting on chairs extended their arms and supported the same by grasping sticks butting against the chairs. This represented the two double cantilevers. The central girder was represented by a short stick slung from one arm of each man, and the anchorages by ropes extending from the other arms to a couple of piles of brick. When stresses are brought on this system by a load on the central girder, the men's arms and the anchorage ropes come into tension and the sticks and chair legs into compression. In the Forth Bridge you have to imagine the chairs placed a third of a mile apart and the men's heads to be 360 feet above the ground. Their arms are represented by huge steel lattice members, and the sticks or props by steel tubes 12 feet in diameter and $1\frac{1}{4}$ inch thick.

I have remarked that the principle of the Forth Bridge is not novel. When Lord Napier of Magdala accompanied me over the works one day he said: "I suppose you touch your hat to the Chinese?" and I replied "Certainly," as I knew that a number of bridges on the same principle had existed in China for ages past. Indeed, I have evidence that even savages when bridging in primitive style a stream of more than ordinary width, have been driven to the adoption of the cantilever and central girder system as we were driven to it at the Forth. They would find the two cantilevers in the projecting branches of a couple of trees on opposite sides of the river, and they would lash by grass ropes a central piece to the ends of their cantilevers and so form a bridge. This is no imagination, as I have actual sketches of such bridges taken by exploring parties of engineers on the Canadian Pacific and other railways, and in an old book in the British Museum I found an engraving of a most interesting bridge in Tibet upwards of 100 feet in span, built between two and three centuries ago, and in every respect identical in principle with the Forth Bridge. When I published my first article on the proposed Forth Bridge some four years ago I protested against its being stigmatized as a new and untried type of construction, and claimed that it probably had a longer and more respectable ancestry even than the arch.

The best evidence of approval is imitation, and I am pleased to be able to tell you that since the first publication of the design for the Forth Bridge, practically every big bridge throughout the world has been built on the principle of that design and many others are in progress.

PIERS.—Having referred thus briefly to the general principle of the Forth Bridge, I will now describe more particularly the details of the structure, commencing with the piers.

There are three main piers, known respectively as the Fife pier, the Inch Garvie pier, and the Queensferry pier, and upon each of these there are built huge cantilevers stretching both ways. The Fife pier stands between high and low water mark, and is separated by a span of 1700 feet from the Inch Garvie pier, which is partly founded upon a rocky island in mid-stream. Another span of 1700 feet carries the bridge to the Queensferry pier, which is at the edge of the deep channel. The total length of the viaduct is about $1\frac{1}{2}$ mile, and this includes two spans of 1700 feet, two of 675 feet, being the shoreward ends of the cantilevers, and fifteen of 168 feet. Including piers, there is thus almost exactly one mile covered by the great cantilever-spans, and another half-mile of via-



FORTH BRIDGE.—BUILDING THE GREAT STEEL CANTILEVERS.

duct-approach. The clear headway under the centre of the bridge is 152 feet at high water, and the highest point of the bridge is 360 feet above the same datum.

Each of the main piers includes four columns of masonry founded on the rock or boulder-clay. Above low water the cylindrical piers are of the strongest flat bedded Arbroath stone set in cement and faced with Aberdeen granite. The height of these monoliths is 36 feet, and the diameter 55 feet at bottom and 49 feet at top, and they each contain forty-eight steel bolts $2\frac{1}{2}$ inches in diameter and 24 feet long to hold down the superstructure.

Below low water the piers differ somewhat in character, according to the local conditions. On the Fife side, one of the piers was built with the aid of a half-tide dam, and the other with a full-tide dam. The rock was blasted into steps, diamond drills and other rock-drills being used. Even this comparatively simple work was not executed without considerable trouble, as the sloping rock bottom was covered with a closely-compacted mass of boulders and rubbish, through which the water flowed into the dam in almost unmanageable quantity. After many months' work the water was sufficiently excluded by the use of cement-bags, and liquid grout poured in by divers under water, and other expedients, and the concrete foundation and masonry were proceeded with.

At Inch Garvie, the two northernmost piers were founded like the preceding, but the two others presented greater difficulties, owing to the depth of water, and had to be dealt with in a different way. Several designs were prepared for these foundations, but it was finally decided, and, as experience proved, wisely, to put them in by what is known as the pneumatic or compressed air process. The conditions of the problem were a sloping, very irregular, and fissured rock bottom, in an exposed seaway, and with a depth at high water of 72 feet. Anything of the nature of a water-tight cofferdam, such as was used at the shallow piers, was out of question, and the plan adopted was as follows:—

Two wrought-iron caissons, which might be likened to large tubs or buckets, 70 feet in diameter and 50 to 60 feet high, were built on launching-ways on the sloping southern foreshore of the Forth. The bottom of each caisson was set up 7 feet above the cutting edge, and so constituted a chamber 70 feet in diameter and 7 feet high, capable of being filled at the proper time with compressed air to enable men to work as in a diving-bell below the water of the Forth. The caisson, weighing about 470 tons, was launched, and then taken to a berth alongside the Queensferry jetty, where a certain amount of concrete, brickwork, and staging was added, bringing the weight up to 2640 tons. At Inch Garvie a very strong and costly iron staging had previously been erected, alongside which the caisson was finally moored in correct position for sinking. Whilst the work described was proceeding, divers and labourers were engaged in making a level bed for the caisson to sit on. The 16-feet slope in the rock bottom was levelled up by bags filled with sand or concrete. As soon as the weight of caisson and filling reached 3270 tons, the caisson rested on the sand-bags and floated no more. The high ledge of rock upon which the northern edge of the caisson rested was blasted away, holes being driven, by rock-drills and otherwise, under the cutting edge, and about 6 inches beyond for the charges. After the men had gained a little experience in this work, no difficulty was found in under-cutting the hard whinstone rock to allow the edge of the caisson to sink, and, of course, there was still less difficulty in removing the sand-bags temporarily used to form a level bed. The interior rock was excavated as easily as on dry land, the whole of the 70-feet diameter by 7-feet high chamber being thoroughly lighted by electricity. Access was obtained through a vertical tube with an air-lock at the top, and many visitors ventured to pass through this lock into the lighted chamber below, where the pressure at times was as high as 35 lbs. per square inch. Probably the most astonished visitors were some salmon, who, attracted by the commotion in the water caused by the escape of compressed air under the edge of the caisson, found themselves in the electric lighted chamber. When in the chamber the only notice of this escape of large volumes of air was the sudden pervadence of a dense fog, but outside a huge wave of aërated water would rise above the level of the sea, and a general effect prevail of something terrible going on below. No doubt the salmon thought they had come to a cascade turned upside down, and, following their instinct of heading up it, met their fate.

Another astonished visitor was a gentleman who took a flat-sided spirit-flask with him into the caisson, and emptied it when down below. Of course the bottle was filled with compressed air, which exploded when passing through the air-lock into the normal atmospheric pressure, the pressure in the bottle being 33 lbs. per square inch. The Garvie piers, notwithstanding the novelties involved in sinking through whinstone rock, at a depth of 72 feet below the waves of the Forth, were completed without misadventure, in less than the contract time. The first of the deep Garvie caissons was launched on March 30, 1885, and both piers were finished to sea-level or above by the end of the year.

At Queensferry all four piers were founded on caissons identical in principle with those used for the deep Garvie piers. The deepest was 89 feet below high water, and weighed 20,000 tons; the shallowest of the four was 71 feet high, the diameter in all cases, as at Garvie, being 70 feet at the base. Some differences in detail occurred in these caissons as compared with Garvie, owing to the differences of the conditions. Thus, instead of a sloping surface of rock the bed of the Forth was of soft mud to a considerable depth, through which the caissons had to be sunk into the hard boulder-clay. Double skins were provided for the caissons, between which concrete could be filled in to varying heights if necessary, so that greater weight might be applied to the cutting edge where the mud was hard than soft. This annular wall of concrete also gave great strength to resist the hydrostatic pressure outside the caisson, for it must be understood that the water was excluded both below and above the working chamber.

The process of sinking was as follows:—The caisson being seated on the soft mud, which, of course, practically filled the working chamber, air was blown in, and a few men descended the shaft or tube of access to the working chamber in order to clear away the mud. This was done by diluting it to the necessary extent by water brought down a pipe under pressure, and by blowing it out in this liquid state through another pipe by means of the pressure of air in the chamber. It was found that the mud sealed the caisson so that a pressure of air considerably in excess of that of the water outside could be kept up, and it was unnecessary to vary the pressure according to the height of the tide. In working through this soft mud both intelligence and courage were called for on the part of the men, and it is a pleasure and duty for me to say that the Italians and Belgians engaged on the work were never found wanting in those qualifications. There was always a chance of the caisson sinking suddenly or irregularly, and imprisoning some of the men; and, indeed, on one occasion a few men were buried up to their chins in the mud, and on another the caisson gave a sudden drop of 7 feet. Happily no serious accident happened, although I confess that I felt a little apprehensive myself, as I was familiar with the details of an accident with a similar caisson sunk in the bed of the Neva, at St. Petersburg, in 1876. In that case the wet mud rose rapidly in the working chamber when the caisson sank suddenly 18 inches one day, and of the twenty-eight men in the

chamber nine remained imprisoned. Of these, two managed to get their heads into the shaft of access, and were taken out alive after twenty-eight hours, and the remaining seven were smothered in the mud. It was nearly a year before sinking was renewed. Again, in 1877, one of the air-locks suddenly gave way, and of the men then in the chamber, three escaped uninjured, nine were blown out by the rush of air, and, falling into the water and on craft, were mortally injured, whilst twenty were smothered in the caisson. It was thirteen months before the chamber was accessible, and then the vitiated atmosphere in the charnel-house below rendered it very difficult to work. Happily we had no such experiences at the Forth.

With one of our caissons we unfortunately had an accident and loss of life, which, although it had nothing to do with the sinking of the caisson, as in the Neva Bridge, was indirectly due to the same cause, viz. the softness of the mud bottom. On New Year's Day, 1885, the south-west Queensferry caisson, which had been towed into position, and weighted with about 4000 tons of concrete, stuck in the mud, and, instead of rising with the tide, remained fixed so that the water flowing over the edge filled the interior. The 4000 tons of water caused the caisson to sink further in the mud, especially at the outer edge, and to slide forward and tilt. The contractors determined to raise the skin of the caisson until it came above water-level, and then pump out and float the caisson back into position. About three months were occupied in doing this, but when pumping had proceeded a certain extent the caisson collapsed, owing to the heavy external pressure of the water, and two men were killed. It was necessary then to consider very carefully what had better be done, as the torn caisson was difficult to deal with. Finally it was determined to case it in "tubbing" of whole balks of timber strutted with ring girders and rakers This was a very tedious work, as every balk had to be fitted water-tight to its neighbours by divers. Finally, on October 19, 1885, or between nine and ten months after the first accident, the caisson, to the relief of everyone, was floated into position and the sinking proceeded without further difficulty, this, the last of the main piers, being completed in March 1886, or almost exactly two years after the first caisson was floated out. No doubt some of my hearers have passed through air-locks and experienced the physiological effects of compressed air, one of the first of which is a painful pressure on the drums of the ears. It is necessary to restrict the hours of work, and even then most men suffer more or less inconvenience. Pains in the limbs are generally relieved by galvanism; a long continuance often leads to paralysis if the depth is great. At the St. Louis Bridge in America, for example, out of 600 workmen who worked in the compressed air, 119 were attacked, 16 died, and 2 were crippled. We had no deaths directly attributable to the air-pressure. Personally I felt no inconvenience whatever. Photographs were taken in the caisson, a total lighting power of 6000 candles and an exposure of as much as 15 minutes in some cases being given. Owing to the fog formed when the air blew under the edge the results were not so good as could be wished, the eyes especially coming out in glaring spectral fashion.

SUPERSTRUCTURE.—I must now say a few words respecting the design, manufacture, and erection of the superstructure.

Design.—I have already illustrated the principle of the cantilever bridge, and need only deal with the details. At the Forth, owing to the unprecedented span and the weight of the structure itself, the dead load is far in excess of any number of railway trains which could be brought upon it. Thus the weight of one of the 1700-feet spans is about 16,000 tons, and the heaviest rolling load would not be more than a couple of coal trains weighing say 800 tons together, or only 5 per cent. of the dead weight. It is hardly necessary therefore to say that the bridge will be as stiff as a rock under the passage of a train. Wind, even, is a more important element than train weight, as with the assumed pressure of 56 lbs. per square foot the estimated lateral pressure on each 1700-feet span is 2000 tons, or two and a half times as much as the rolling load. To resist wind the structure is "straddle-legged," that is, the lofty columns over the piers are 120 feet apart at the base and 33 feet at the top. Similarly, the cantilever bottom members widen out at the piers. All of the main compression members are tubes, because that is the form which with the least weight gives the greatest strength. The tube of the cantilever is, at the piers, 12 feet in diameter and 1¼ inch thick, and it is subject to an end pressure of 2282 tons from the dead load, 1022 tons from the trains, and 2920 tons from the wind; total, 6224 tons, which is the weight of one of the largest Transatlantic steamers with all her cargo on board. The vertical tube is 343 feet high, 12 feet in diameter, and about ⅝ inch thick, and is liable to a load of 3279 tons. The tension members are of lattice construction, and the heaviest-stressed one is subject to a pull of 3794 tons. All of the structure is thoroughly braced together by "wind bracing" of lattice girders, so that a hurricane or cyclone storm may blow in any direction up or down the Forth without affecting the stability of the bridge. Indeed, even if a hurricane were blowing up one side of the Forth and down the other, tending to rotate the cantilevers on the piers, the bridge has the strength to resist such a contingency. We have had wind-gauges on Inch Garvie since the commencement of the works, and know, therefore, the character of the storms the bridge will encounter. The two heaviest gales were on December 12, 1883, and January 26, 1884. On the latter occasion much damage was done throughout the country. At Inch Garvie the small fixed gauge was reported to have registered 65 lbs. per square foot, but I found on inspection that the pointer could not travel further, or it might have indicated even higher. I did not believe this result, and attributed it to the joint action of the momentum of the instrument, and a high local pressure of wind too instantaneous in duration to take effect upon a structure of any size or weight. The great board of 300 square feet area on the same occasion indicated only 35 lbs. per square foot, and I doubt much if the pressure would have averaged more than 20 lbs. on so large a surface as the bridge.

Manufacture.—The bent plates required for the tubes of the Forth Bridge would, if placed end to end, stretch 42 miles. Special plant had to be devised for preparing these plates. Long furnaces, heated in some instances by gas-producers, and in others by coal, first heated the plates, which were then hauled between the dies of an 800-ton hydraulic press, and bent to the proper radius. When cool, the edges were planed all round, and the plates built up into the form of a tube in the drilling-yard. Here they were dealt with by eight great travelling machines, having ten traversing drills radiating to the centre of the tube, and drilling through as much as 4 inches of solid steel in places. A length of 8 feet was drilled in a day of twenty-four hours. When complete, the tubes were taken down, the plates cleaned and oiled, and stacked ready for erection.

The tension members and lattice girders generally are of angle bars, sawn to length when cold, and of plates planed all round. Multiple drills tear through immense thickness of steel at an astonishing rate. The larger machines have ten drills, which, going as they do, day and night, at 180 revolutions per minute, perform work equivalent to boring an inch hole through 280 feet thickness of solid steel every twenty-four hours. About 4 per cent. of the whole weight of steel delivered at the works leaves it again in the form of shavings from planing-machines and drills. The material used throughout is Siemens's steel of the finest quality, made at the Steel

Company's Works in Glasgow, and at Landore in South Wales. Although one and a half times stronger than wrought iron, it is not in any sense of the word brittle, as steel is often popularly supposed to be, but it is tough and ductile as copper. You can fold half-inch plates like newspapers, and tie rivet-bars like twine into knots. The steel shavings planed off form such long, true, and flexible spirals, that they are largely used for ladies' bracelets when fitted with clasps and electro-plated.

Erection.—Facility of erection is one of the most important desiderata in the case of the Forth Bridge. Owing to the 200 feet depth of water, scaffolding is impossible, and the bridge has to constitute its own scaffolding. The principle of erection adopted was, therefore, to build first the portion of the superstructure over the main piers, the great steel towers, as they may be called, although really parts of the cantilever, and to add successive bays of the cantilever right and left of these towers, and therefore balancing each other, until the whole is complete. This being the general principle, a great deal yet remained to be done in settling the details. What was finally settled, and is now in progress, is as follows:—

After the skewbacks, horizontal tubes, and a certain length of the verticals as high as steam-cranes could conveniently reach were built, a lifting-stage was erected. This consisted of two platforms, one on either side of the bridge, and four hydraulic lifting-rams, one in each 12-feet tube. To carry these rams cross-girders were fitted in the tubes capable of being raised so as to support the rams and platform as erection proceeded, and steel pins were slipped in to hold the cross-girders. Travelling cranes are placed on the platforms, and these cranes, with the men working aloft, are of course raised with the platforms when hydraulic pressure is let into the rams. The mode of procedure is to raise the platform 1 foot, and slip in the steel pins to carry the load whilst the rams are getting ready to make another stroke of 1 foot. When a 16-feet lift has been so made, which is a matter of a few hours, a pause of some two or three days occurs to allow the riveting to be completed. The advance at times has been at the rate of three lifts, or 48 feet in height, in a week.

The riveting appliances designed by Mr. Arrol are of a very special and even formidable character, each machine weighing about 16 tons. It consists essentially of an inside and outside hydraulic ram mounted on longitudinal and annular girders in such a manner as to command every rivet in the tubes, and to close the same by hydraulic pressure. Pipes from the hydraulic pumps are carried up inside the tubes to the riveters, and oil furnaces for heating the rivets are placed in convenient spots, also inside the tubes. By practice, and the stimulus of premiums, the men have succeeded in putting in 800 rivets per day with one of the machines, at a height of 300 feet above the sea, which, in fact, is more than they accomplished when working at ground level. Indeed, by the system of erection adopted, the element of height is practically annihilated, and with ordinary caution the men are safer aloft than below, as in the former case they are not liable to have things dropped on their heads.

The cantilever will be erected and riveted in precisely the same manner as the great towers, but owing to the overhang temporary ties will occasionally be required. The centre girder itself will be similarly erected, one half being temporarily added on to the extremity of each cantilever, and when the two ends meet at the centre of a 1700-feet span they will be connected, and the temporary joints, with the cantilevers, released. Roller joints are provided at the cantilever ends for expansion, and at the main piers the whole superstructure rests on lubricated sliding bed-plates.

The system of erection by overhanging offers great advantages as regards safety, as each successive part of the superstructure is riveted up and completed before a further portion is added. In the case of an ordinary bridge the whole superstructure must first be temporarily bolted up on scaffolding, and in that condition is liable to be swept away by flood or hurricane at any moment.

There is nothing new under the sun, and therefore you will not be surprised to hear that in 1810, a certain Mr. Pope proposed to construct a cantilever bridge, of 1800 feet span, across the East River, in New York, and, indeed, exhibited a 50-feet model of the same.

I have described the process of erecting the Forth Bridge in sober prose; if I had thought of doing it in verse I should have appropriated bodily Mr. Pope's lyrical version of his intended operations at the East River, of which the following is a sample:—

> "Each semi-arc is built from off the top,
> Without the aid of scaffold, pier, or prop;
> By skids and cranes each part is lowered down,
> And on the timber's end grain rests so sound.
> Sure all the bridges that were ever built,
> Reposed their weight on centre, pier, or stilt;
> Not so the bridge the author has to boast,
> His plan is sure to save such needless cost;
> A ladder on each side is lowered down,
> And shifted from the fulcrum to the crown."

To carry out the work at the Forth Bridge there is an army of 3500 workmen, officered by a proportionate number of engineers. Everything, except the rolling of the steel plates, is done on the spot, and consequently there are literally hundreds of steam and hydraulic engines and other machines and appliances too numerous to mention, many of them being of an entirely original character.

It is, of course, impossible to carry out a gigantic work of the kind I have had the honour of bringing before the Institution without paying for it, not merely in money, but in men's lives. I shall have failed in my task if you do not, to some extent, realize the risks to which zealous and plucky workmen will be sure to expose themselves in pushing on with the work of erecting the Forth Bridge. Speaking on behalf of the engineers, I may say that we never ask a workman to do a thing which we are not prepared to do ourselves, but of course men will, on their own initiative, occasionally do rash things. Thus, not long ago a man trusted himself at a great height to the simple grasp of a rope, and his hand getting numbed with cold he unconsciously relaxed his hold and fell backwards, a descent of 120 feet, happily into the water, from which he was fished out little the worse after sinking twice. Another man going up in a hoist the other day, having that familiarity with danger which breeds contempt, did not trouble to close the rail, and, stumbling backward, fell a distance of 180 feet, carrying away a dozen rungs of a ladder with which he came in contact, as if they had been straws. These are instances of rashness, but the best men run risks from their fellow-workmen. Thus a splendid fellow, active as a cat, who would run hand over hand along a rope at any height, was knocked over by a man dropping a wedge on him from above, and killed by a fall of between one and two hundred feet. There are about 500 men at work at each main pier, and something is always dropping from aloft. I saw a hole 1 inch in diameter made through the 4-inch timber of the staging by a spanner which fell about 300 feet, and took off a man's cap in its course. On another occasion a dropped spanner entered a man's waistcoat and came out at his ankle, tearing open the whole of his clothes, but not injuring the man himself in any way.

Happily, there is no lack of pluck amongst British workmen; if one man falls another steps into his place. Difficulties and accidents necessarily occur, but like a disciplined regiment in action we close up the ranks, push on, and step by step we intend to carry on the work to a victorious conclusion.

UPPER WIND-CURRENTS NEAR THE EQUATOR, AND THE DIFFUSION OF KRAKATÃO DUST.

THE crude idea that the trade-winds on either side of the equator met in the doldrums, and that then the air rising upwards flowed backwards as a return south-west current in the northern hemisphere, and as a north-west current in the southern hemisphere, has been modified by the more modern discoveries that the atmosphere is not composed of horizontal layers of air moving in different directions, but that, as a rule, there is a regular continuous successive veering of the wind as we ascend. It is not usual to find a southerly wind on the surface, and for some height above, and then abruptly a westerly current also of a certain thickness; for cloud-observations show that over a surface south wind the upper currents may be from south-by-west at quite a low level, from south-south-west a little higher up, then successively from south-west and west-south-west as we ascend, and perhaps from west at the altitude of the highest cirrus. We must, in fact, look upon the atmosphere as circulating in the form of a continuous complex screw.

Innumerable observations show that, as a rule, there is a very definite law of the vertical succession of the upper currents. Stand with your back to the surface wind, and the upper currents will come successively more and more from your left hand the higher they are. The rule is reversed in the southern hemisphere, for there the upper currents come successively more and more from the right. For instance, with a southerly wind in London, the clouds will come more and more from the west the higher they are, while in Australia they would come more and more from the east.

But during my two meteorological voyages round the world I have discovered some very remarkable exceptions to this law in that interesting part of the world, meteorologically, that lies between the equator and the doldrums. These have so important a bearing, not only on the whole problem of the circulation of the atmosphere from the equator to the Pole, but also on the remarkable diffusion of dust from the volcano of Krakatão, that I propose to give a short account of these researches in this article.

In the Atlantic, the doldrums lie north of the equator at all seasons of the year. Between 20° and 30° W. longitude they range from about 3° N.; in winter, to 11° N. in summer time. In the Gulf of Guinea, the position of the doldrums cannot be accurately defined, but they probably range from about 5° to 10° N. of the equator. There is, however, a striking difference in the direction of the winds between the equator and the doldrums in the eastern and western portions of the Atlantic. In the Gulf of Guinea, the south-east trade turns to south-west and forms a south-west monsoon; while west of about 15° W. longitude the south-east trade remains from nearly in the same direction as before it crossed the line.

In the Indian Ocean, the position of the doldrums varies enormously at different seasons. From about November to March the doldrums are 5° to 10° S. of the line, and the north-east monsoon draws into the well-known north-west monsoon as it crosses the equator. From April till September the doldrums must be somewhere to the north of the line; but, contrary to the opinion of Dove and others, the Indian meteorologists now believe that the south-west monsoon is not linked up regularly with the south-east trade. As the evidence for this belief is not yet published, we can say nothing about it, though we shall have to refer to the point later on.

The words rotation, circulation, and veering of wind are unfortunately used so vaguely by different writers that it may be well to define them more precisely before we discuss the general circulation of the equator.

"Rotation" should be confined exclusively to the manner in which the surface wind blows round areas of high or low pressure. For instance, we may say that the wind rotates counter-clockwise round a cyclone in the northern hemisphere.

"Circulation" should be applied to the general movement of a whole mass of air extending over a certain breadth and height. For instance, the air in a cyclone rotates round and in below, round and out at high levels; and the whole system makes up the general circulation of a cyclone. Or, again, the whole motion of the atmosphere into the doldrums, then upwards and more or less polewards, should be called the general circulation in the vicinity of the equator.

"Sequence" of wind should be applied to the changes in the direction of the wind which take place during any interval of time as a cyclone passes over a station. This veering or backing of the wind has unfortunately been too often called the rotation of the wind. The confusion here, as often, arises from sometimes talking of the motions of a mass of air extending over a large area at a given moment, and sometimes of the successive motions of the air at a single station during a certain interval of time. Some writers make matters worse by not only drawing the plan of a cyclone on a chart, but also by putting in small circles at different stations to show how the wind would go round as the cyclone drifted past. The confusion is direful.

"Vertical succession" should be used to denote the gradual successive directions of the upper currents, as has been already explained.

The two sections of weather across the Atlantic which I made were taken, the one in July, between Rio Janeiro and Teneriffe; the other in December, between Teneriffe and Capetown. A short account of the observations were published in NATURE, vol. xxxiii. p. 294, so that the general results only need be stated here.

Between Rio and Teneriffe, while south of the line, the low or middle clouds over the south-east trade invariably came from some point to the right of the surface when you stood with your back to the wind; *i.e.* if the surface wind was south-east the low clouds would drive from about east-south-east. This is the usual vertical succession of the southern hemisphere

But north of the line, when, for reasons which cannot be discussed here, the south-east trade did not turn into south-west, as might have been expected, the upper currents continued to follow the succession of the southern hemisphere, instead of conforming to the law of the northern hemisphere. In the doldrums, which extended from about 8° to 13° N., the same rule obtained, and the middle layer of cloud over some "cats' paws" of south-east wind drove from the east. To show how difficult it is to get cirrus observations in the tropics, I may mention that this was the highest layer I was able to record during this part of the voyage.

In the north-east trade I only got one unsatisfactory observation in 22° N., 19° W., which gave a middle layer of north-north-east wind over an east-north-east surface trade. This is the contrary of what might have been expected.

In the second section, between Teneriffe and Capetown, the lower layers of cloud in the north-east trade—from 30° N. to the doldrums in 5° N.—invariably came from some point to the left of the surface wind, generally from south or south-by-west. This is the usual vertical succession of the northern hemisphere.

But as we entered the doldrums, in 5° N., a totally different wind-system became apparent. Over the oily calm of that district I could just detect, through the universal haze and gloom, a middle current from the east; and when a few hours later we picked up the south-west monsoon of the Gulf of Guinea—here coming from south-by-west—the low clouds came from south-east. This con-

tinued till we reached the line, and the single observation that I got of high cirrus in 1° N. lat. showed an easterly current at that level. The above results are very curious, for the usual idea is that the south-east trade on crossing the equator becomes a south-west wind under the influence of the earth's rotation; but here, though the surface wind appears to conform to the usual rotation of the air round a low pressure, the upper currents maintain the vertical succession of the southern hemisphere.

After crossing the equator ourselves, the wind turned to south-by-east, or south-south-east; and as far as 18° S., beyond which we need not follow them, the lower currents were either identical in direction with the surface winds, or else a very little more easterly—that is, they followed the normal vertical succession of the southern hemisphere.

I have endeavoured to show all this in a diagrammatic form in Fig. 1, where the full arrows denote the surface wind; the broken-lined arrows the direction of the low or middle-level clouds; the dotted arrows that of the highest cirrus. A couple of arrows to denote the typical succession over an extra-tropical south-west wind are inserted on the upper left-hand corner of the figure.

The observations in the Indian Ocean have also been published in NATURE, vol xxxii. p. 624, and vol. xxxiii. p. 460. They were taken during two trips—one from Aden to Cape Lewin, in February, the other from Cape Lewin to Colombo, in the same month of the following year.

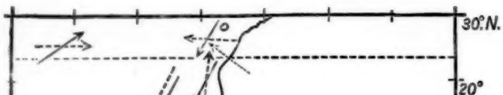


FIG. 1.—Surface and upper currents in the Atlantic.

This is the season of the north-west monsoon. The results were very accordant, and showed conclusively that in vertical succession the upper currents over the north-east monsoon were always more from the east than the surface wind, as is usual in the northern hemisphere. No high cirrus was ever observed in this part of the ocean.

In the north-west monsoon, between the equator and the doldrums, low and middle currents came from north or north-east, and the only two observations on the highest cirrus showed an easterly current at that level.

In the south-east trade, the low or middle currents were generally about from the same direction as the surface wind, or else a little more from the east. This is the normal succession of the hemisphere. Thus we see an extraordinary analogy to what occurs in the Atlantic. When the north-east monsoon is drawn across the equator, towards the low pressure of the doldrums, the surface wind seems to pick up the westerly component of the earth's rotation in the usual manner; but the upper currents retain the vertical succession of the northern hemisphere.

The results of all the observations are given in a diagrammatic form in Fig. 2. It will be remarked how few observations there are of cirrus; this is because it is so rarely seen in those latitudes. It is certain that, on the southern and western edges of the great anticyclone which controls the south-east trade, the highest currents would have come more or less from the north-west, as is marked at Mauritius.

I have unfortunately got no equatorial observations from the Pacific, but they would most likely be very similar to those in the Atlantic.

However, the upshot of all those which we have just described is to show that when the trades or monsoons meet they do not interlace, as has been suggested by Maury, but that the upper winds combine in a generally easterly current, and probably diverge only slightly polewards on either side. I am unable to form any opinion as to the velocity of this current.

I have often been asked how far all this bears on the remarkable distribution of dust from Krakatão, and the answer is very simple. The great explosion of Krakatão took place on August 26; that is to say, during the south-west moonsoon of the Indian Ocean. The distribution of the surface and upper currents is then very different from that in our last diagram. The south-east trade, with its upper easterly currents, extends all over the Indian Ocean, and Malaysia south of the line, including Krakatão, marked K in the figure. North of the equator the surface wind turns to the south-west, but we know nothing of the motion of the upper currents.

Now, assuming that the blue sun and unusual twilight

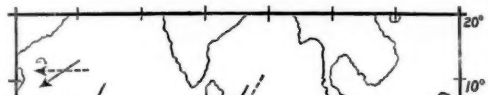


FIG 2.—Surface and upper currents in the Indian Ocean in February.

glows were equally the product of volcanic dust as the fall of actual ashes, the sequence of the first appearance of these phenomena in different parts of the world, dating from August 26, was as follows:—

On August 26, the day of the eruption, ashes, lofty haze, or red twilights are reported south of the equator, nearly 20° of longitude west of Java, from one station in Sumatra, just north of the line, and from near Formosa.

Next day, the 27th, similar phenomena were reported from many stations in the Indian Ocean, south of the equator, as far west as Mauritius and the Seychelles; while north of the line, strange appearances were reported for the first time in Borneo and Ceylon.

On the 28th, the haze and abnormal glows had extended to Natal on one side and Japan on the other.

No important extension of the area is reported on August 29; but by the 30th unusual coloration of the sky is reported from various parts of the South Atlantic, and Guiana, and, what is specially noticeable, from about the Cape Verd Islands, north of the equator.

On the 31st, another station in Brazil, and also a West Indian island, report a strange look about the sun or sky; while on September 1 the same was noted at Guayaquil, on the west coast of South America; and in a quite unexpected locality, far away from there,—New Ireland.

September 2 was characterized by an outburst of

coloured suns all over the northern provinces of South America; while between the 3rd and 4th of the same month the glows extended across the Pacific both north and south as far as the Society and Gilbert Islands, and were reported from two stations in New Britain.

By September 5 the Sandwich Islands were reached; while the outburst of glows in Southern India did not commence till about the 6th to 8th of the same month.

The northward extension of the dust all this time was very small, and not widespread. Isolated phenomena are reported from Formosa on August 26, and from Japan on the 28th, but I am unable to say whether the glows which appeared in the Sandwich Islands on September 5, had come *viâ* Japan, or across South America.

Thus the general system of the dust-flow appears to have been very simple. The great dust-stream was carried for the first twenty-four hours by the normal easterly upper currents over the south-east trade, at the extraordinary rate of more than 120 miles an hour, but hardly extended north of the line. Three days after the eruption we find the products of Krakatão in Guiana, the South Atlantic and also north of the line in the Cape Verd Islands. Just to the south of the latter we know that the south-east trade with its attendant upper currents crosses the equator. Then all the north of South America was invaded; and six or seven days after the first outburst, the Pacific Islands—south of, or on the line—were also overshadowed.

In fact we may say that the great stream of Krakatão dust was carried nearly round the world by the usual upper winds of the south-east trade, in which the dust was first ejected, at a rate of about 120 miles an hour, and that the dust spread very slowly either north or south of the main current.

There is one inference from this which is very important in any theory of the general circulation of the atmosphere from the equator to the Poles. The main body of the equatorial circulation is in an easterly direction, so that the whole mass of air going towards the doldrums does not rise up and flow backwards on itself directly towards the Pole; and though the highest currents over the Polar limit of both the south-east and north-east trades are from north-west and south-east respectively, still the poleward motion near the equator is very small.

The high velocity of 120 miles an hour is certainly more than would have been expected; but we have very few observations on the rate of motion of the highest clouds. Hildebrandsson has, however, reported from Upsala one velocity of about 112 miles per hour for a cirrus at 28,000 feet (50 metres per second at 8559 metres); and several velocities ranging between that figure and 90 miles per hour.

There would be nothing, then, outrageous in the assumption of a velocity of 120 miles an hour for the easterly current over the equator to account for the high speed of the diffusion of Krakatão dust; and it is also satisfactory to know that the general direction of the flow is in accordance with the most recent researches on the vertical succession of the upper currents near the equator.

RALPH ABERCROMBY.

BERNARD STUDER.

AMONG the magnates of Swiss geology, no name has held a more honoured place than that of Bernard Studer, who now at the ripe age of ninety-three years has passed away. Upwards of sixty years ago he began his scientific career by the study of some of the geological problems presented by the rocks of his native country. From the molasse of the lower grounds he soon climbed into the higher Alps, and distinguished himself as one of the foremost pioneers who grappled with the intricate problems in stratigraphy which these mountains present. With patient toil he extended year by year his acquaintance with the various portions of the chain, publishing from time to time notices of his labours, and preparing materials for a geological map of the whole region. In association with A. Escher von der Linth he pursued these labours until the two fellow-workers were enabled to give to the world their great map of Switzerland, which, though only an outline of the geology of the Alps, will remain as an enduring monument of the geological prowess of its authors. No one who has not climbed the mountains with that map in hand can form any adequate conception of the physical labour, mental exertion, and happy geological intuition which its preparation required.

Studer's contributions to the glacial geology of the Alps brought him into intimate personal relations with many English geologists. All who passed through Berne tried to see the venerable Professor, who retained, in spite of his weight of years, his keen interest in the progress of his favourite science. His papers, published in various scientific journals, make a long list. But he was also the author of some separate works. Besides the great map of Switzerland, he published several volumes on Swiss geology, the most important of which was his "Geologie der Schweiz," which appeared in two volumes in 1851-53. Less known perhaps, but full of suggestive matter, is his "Lehrbuch der physikalischen Geographie und Geologie," which was issued as far back as 1844. This work was one of the earliest in which the processes of physical geography were discussed from the geological side, and showed how wide and thoughtful had been the observations of the author, especially among the phenomena to be witnessed in Switzerland. Another of the old lights of geology has been extinguished by the death of Bernard Studer, whose kindly presence and helpful courtesy will be affectionately remembered by everyone who has been fortunate enough to come in contact with him.

NOTES.

AN important Bill dealing with the question of technical education has been introduced into the House of Commons by Sir Henry Roscoe. The Bill empowers any School Board, local authority, or managers of a public elementary school, to provide day technical and commercial schools and classes for the purpose of giving instruction in any of certain subjects. These include the several science subjects which are specified in the Directory of the Science and Art Department, and in which that Department undertakes to examine. The following subjects are also included: the use of ordinary tools, commercial arithmetic, commercial geography, book-keeping, French, German, and other foreign languages, and freehand and machine drawing. The addition of other subjects may be sanctioned from time to time by the Committee of Council on Education or by the Science and Art Department. For the purpose of carrying on these schools and classes, the power of School Boards, other local authorities, and school managers is to be in every respect the same as for providing ordinary elementary schools. They are to have power to provide, or contribute to the maintenance of, laboratories and workshops in endowed schools for the purpose of carrying on classes or instruction under the Bill. All these schools and classes are to be subject to the inspection of the officers of the Committee of Education or of the Science and Art Department. Before a scholar is admitted he must have passed the Sixth Standard or some equivalent examination. The Education Committee and the Science and Art Department are authorized to give grants on such conditions as they may lay down for any of the subjects taught. For the purpose of obtaining grants a technical school or class must be one carried on under minutes to be made by the

Science and Art Department, and laid on the table of the House of Commons in the same way as the minutes that regulate the grants of the Education Department.

ON Tuesday afternoon the new Science and Art Schools which have been erected (at a cost of £17,000) in connexion with Sir Andrew Judde's School, Tunbridge, were formally opened by the Lord Mayor of London. Among those who addressed the company present at the ceremony was Prof. Judd, who referred to Mr. John Morley's idea that science is likely to retaliate on literature for the subservient position it has been so long compelled to occupy. All who had any authority to speak on behalf of science, said Prof. Judd, fully recognized the value of a true literary training, which taught men how best to express the thoughts arising from the trained mind, and the store of facts which science supplied. People must recognize, however, that the time had come when science must take her proper place in the education of the country; for if they did not, other nations would, to the destruction of all our pre-eminence.

ANOTHER serious loss has been inflicted on the cause of geology in this country by the death of Mr. Champernowne, of Dartington Hall, Totnes. Representative of an old Devonshire family, and living in the ancestral home, he was a country gentleman of the best type. At the same time, he devoted himself with singular ardour to geology and especially to the study of the complicated structure of the Devonian rocks of his own district. He had with his own hand mapped the subdivisions of these rocks in far ampler detail than had ever before been attempted, and with a skill and success worthy of the best-trained professional geologist. He lately generously presented his maps to the Geological Survey, with a view to the projected publication of a new edition of the Survey maps of the district. It was while engaged in revising some of his lines for this purpose that he aggravated a previous cold, and brought on congestion of the lungs, which carried him off after an illness of only a few days. His geological ardour was fully equalled by his courtesy and kindness, which endeared him to a wide circle of friends who mourn his early death.

PROF. VULPIAN, the eminent French physiologist, died of pneumonia on the 18th inst. He was sixty-one years of age. For some time he was Assistant Professor in the Museum of Natural History in Paris, but afterwards he was made Professor of Pathological Anatomy in the Paris Medical School. He was appointed Member of the Academy of Sciences in 1876, and Perpetual Secretary in 1886. His principal works relate to the vasomotor system, the diseases of the nervous system, the digestive process, and the physiological action of curare, strychnine, and some other drugs. Before the short illness of which he died, he was giving lectures on the respiratory function; and he was about to publish an important book on the cerebral functions. He was a most conscientious investigator, and his death is greatly regretted by French men of science. The funeral took place on Saturday last, and was attended by a large crowd of friends and students.

THE anniversary meeting of the Royal Geographical Society was held on Monday, when General R. Strachey, who has been elected President, delivered the annual address. After paying a high tribute to his predecessor, Lord Aberdare, and noticing the losses of the Society by death during the past year, General Strachey went on to speak on the subject of geographical education. He then reviewed the chief geographical events of the year, and traced the progress that has been made in geographical knowledge since the beginning of the Queen's reign.

AT the last meeting of the Council of University College, Liverpool, Mr. R. J. Harvey Gibson was appointed to the Lectureship of Botany, vacant by the resignation of Dr. Shearer.

MR. EDGAR M. CROOKSHANK, M.B. (Lond.), has been appointed Lecturer on Bacteriology by the Council of King's College, London.

RATHER more than a year ago (vol. xxxiii. p. 361) we reviewed a "Manual of Bacteriology," by Mr. Edgar M. Crookshank. A new edition has now been issued, and the author has increased the value of the work not only by revising it throughout and bringing it up to date, but by recasting the systematic part. He has written new chapters on the general morphology and physiology of Bacteria, on antiseptics and disinfectants, and on immunity; and seventy-three illustrations have been added. He also gives a useful list of references to works on bacteriology.

IN the Annual Report of the Belfast Naturalists' Field Club for the year ended March 31, 1870, it was stated that the Committee considered it advisable that the Club should prepare complete lists of the fauna, flora, geology, and archæology of Ulster. This purpose has been kept steadily in view, and twenty-one separate papers have been issued, illustrated by twenty-seven plates. These papers have now been brought together in what is intended to be the first of a series of volumes. The volume is entitled "Systematic Lists illustrative of the Flora, Fauna, Palæontology, and Archæology of the North of Ireland," and contains the results of much careful and conscientious work. Among the papers is a very useful one by Mr. William Gray on the cromlechs of Antrim and Down. The list is complete, and each of the monuments has been examined by the author, and, as far as possible, measured and sketched. Mr. Charles Elcock contributes notes on the prehistoric monuments at Carrowmore, near Sligo. Both of these papers are accompanied by good illustrations.

A GEOGRAPHY of the Malay Peninsula, Indo-China, the Eastern Archipelago, the Philippines, and New Guinea, by Prof. A. H. Keane, has just been published by Mr. Edward Stanford. The author's primary aim has been to produce a work which may meet the requirements of teacher and pupil in the Straits Settlements, and in the other colonies directly interested in the regions dealt with. The book ought, however, to be of considerable service to students at home. Prof. Keane knows his subject thoroughly, and his treatment of it is in accordance with the methods of the highest authorities on geographical science.

THE Deutsche Seewarte and the Danish Meteorological Institute have just issued the first quarter of a fresh series of daily synoptic charts, commencing with December 1883. The charts show the conditions of weather over the North Atlantic and a part of the adjacent continents, on each morning, from the data collected by both institutions. The period now embraced by the charts is from September 1873 to September 1876, and from December 1880 to February 1884—excepting from September 1882 to August 1883—being part of the thirteen months selected by the Meteorological Council for their synchronous charts; and the whole work forms a valuable contribution to our knowledge of the causes of the weather changes which generally affect this country. A work of a similar nature is being carried out for the Indian Ocean by Dr. Meldrum, of the Mauritius, for the year 1861, but only the charts for the first three months have yet appeared.

THE *Annalen der Hydrographie und maritimen Meteorologie* of Berlin for April last contains the results of observations taken on board the German warship *Habicht* during her stay at Cameroon from April 1885 to September 1886. The maximum temperature in the harbour was 88°·0 in May 1885, and the minimum 71°·2 in June 1885. The amount of rainfall is not stated, but the number of wet days was most frequent between

April and October; the wet season began in June and ended in October. Lightning was observed almost daily, accompanied at times by heavy thunderstorms. Tornadoes were most frequent in June, October, and November. They lasted about fifteen to twenty minutes, and were generally preceded by a threatening bank of clouds rising over the land, accompanied by a heavy downpour lasting for several hours. The tides were irregular; for instance, there was scarcely any tidal current in the harbour in the beginning of October 1886, but only a slight rise of the water, so that often the ship did not swing.

ON the night of March 15, at about 8 p.m., a most remarkable display of aurora borealis was observed at Throndhjem, in Norway. It first appeared in the east in the form of a streamer, which suddenly flashed upwards to the zenith, and joined another one shooting up from the west; a perfect and symmetrical arc being thus formed right across the sky, one of the bases of which rested on the horizon at the ridge Stenobjerget, and the other at the fortress of Christiansten. The arc emitted a steady white brilliant light, in the centre of which a nucleus of light appeared, more brilliant still. After remaining perfectly stationary and without any undulating motion along it for about a quarter of an hour, the arc moved slowly a little to the northwards, parallel with its former position. The light then began to be diffused, but the aurora remained in the sky till nearly 10 o'clock, although with less intensity.

DR. M. A. VEEDER writes to us from Lyons, New York, that an aurora was seen there on Saturday evening, April 23. Streamers were numerous and active from 10 to 10.30 p.m. There were magnetic perturbations of marked extent at intervals on Saturday and on Sunday. These perturbations became very decided during the evening of Sunday, when there was again an appearance of the aurora, which was, however, very faint.

Science says that the U.S. Geological Survey proposes to collect all attainable information regarding the recent earthquakes in Arizona. Circular letters of inquiry will be sent to residents on the area affected. The disturbed area seems to be a circle of some 400 miles radius, fully one-quarter as large as the Charleston earthquake, and nearly one-third of the area of the Riviera earthquake of last February.

A PAPER by Prof. Milne, containing an interesting account of a series of observations made upon earthquakes in Tokio between March 1884 and March 1885, has lately been printed. Prof. Milne arrives at the practical conclusion that there are at least three ways in which an ordinary building may be to a considerable extent protected from earthquake motion. The first method in a given district is, he says, to make a seismic survey of that area, and then select the locality where the least motion is experienced. A second method is to rest the building at each of its piers upon layers of cast-iron shot. A third method, which is applicable to heavy structures of stone or brick, is to allow them to rest upon foundations on hard ground rising from a deep pit or series of trenches.

AT a meeting of the Council of the National Fish-Culture Association, on Thursday last, a resolution approving of the proposed North Sea Fisheries Institute was unanimously carried. At the same meeting the Secretary reported that a large quantity of trout fry had been presented to various public waters in London and the provinces by the Association. The rest of the fish hatched out this season had been deposited in ponds at the Delaford Park establishment, the aim of the Association being to raise fish entirely from the ova taken from stock bred therein, not from eggs obtained from outside sources. He further stated that the rainbow-trout of California, bred by the Association, had all been maliciously poisoned by arsenic. A severe loss had thus been sustained, the fish being very valuable.

ANOTHER establishment for fish-culture has just been formed at Dulverton, in Somersetshire, by Mr. Frank Langdon. A series of ponds has been made near a tributary of the Exe, which affords an ample supply of pure water. Trout culture will constitute the chief business of the establishment, and a hatchery is being erected to receive the ova, which will be laid down for incubation at the end of the present year.

A *soirée* will be given at University College by the University College Biological Society on Monday, June 6, when Prof. Moseley, F.R.S., will lecture on "Life on the Ocean Surface." Cards of invitation will be sent on application to the Secretary, Mr. Bruce G. Seton.

M. E. QUINQUAUD has been investigating the influence of baths on the chemical phenomena of respiration and nutrition. He finds, by experiments on dogs, that cold baths increase the consumption of oxygen, the consumption being on the average ten times more abundant after the bath than before. Very hot baths exert a like influence, but in a less marked manner. Cold baths (and hot as well, but in a less degree) increase pulmonary ventilation: the quantity of air passed through the lungs is double or treble after the bath. At the same time a greater quantity of carbonic acid is expelled. By the analysis of arterial and venous blood it is shown that the respiratory combustions are very much increased under the influence of cold or hot baths, and it is also shown that the production of blood sugar is greater.

DR. T. MITCHELL PRUDDEN, of New York, has been making some important experiments with a view to determining the effect of freezing on Bacteria. In the case of the *Bacillus prodigiosus*, there were 6300 Bacteria in a cubic centimetre of water before freezing; after being frozen 4 days, 2970; after 37 days, 22; and none after 51 days. Of the *Staphylococcus pyogenes aureus*, there were a countless number before freezing; after 18 days of freezing, 224,598; after 54 days, 34,320; and after 66 days, 49,280. Of the typhoid-fever Bacillus, innumerable before freezing; 1,019,403 after being frozen 11 days; 336,457 after 27 days; 89,796 after 42 days; and 7348 after 103 days. These facts show that certain Bacteria have a remarkable power of resisting the temperature at which ice forms. Dr. Prudden, therefore, recommends that the New York State Board of Health, or other authority, should have power to determine which, if any, of the sources of ice-supply are so situated as to imperil the health of consumers of ice.

AN important new reaction is described in the current issue of the *Comptes rendus* by MM. Varet and Vienne. A current of acetylene was passed through 200 grammes of benzene containing 50 grammes of aluminium chloride during 30 hours, and the oily liquid remaining after removal by washing of the unaltered aluminium chloride was found to yield, on fractional distillation, three distinct products. The first, which came over between 143° and 145°, and which amounted to 80 per cent. of the whole, consisted of pure cinnamene or styrolene, $C_6H_5—CH = CH_2$, a substance occurring in liquid storax (*Liquidambar orientale*), and which was synthetized by M. Berthelot by passing acetylene together with benzene vapour through a tube heated to redness. The second fraction, coming over at 265°-270°, consisted of diphenyl ethane $(C_6H_5)_2 = CH—CH_3$, and the third fraction, boiling at 280°-286°, was found to consist entirely of dibenzyl, $C_6H_5—CH_2—CH_2—C_6H_5$, a solid substance isomeric with diphenyl ethane. These syntheses are extremely interesting, and afford another instance of the singular action of aluminium chloride in enabling us to attack the benzene nucleus.

A CURIOUS series of experiments has just been completed by Drs. Emil Fischer and Penzoldt (*Liebig's Annalen*, B. 239, i. 131) upon the sensitiveness of the sense of smell. These chemists used mercaptan and chlorphenol as their odoriferous substances, and experimented in a room of 230 cubic metres capacity. A gramme of the substance was dissolved in a litre of alcohol; 5 c.c. of the solution were again diluted to a known volume, and 1–3 c.c. of the latter solution measured out into a flask from which a fine jet could be directed by the experimenter to all parts of the room, the air of which was subsequently agitated by the waving of a flag. At a given signal a second experimenter stepped into the room, and took his olfactory observation, which was checked by the independent observation of a third person. The astonishing result was arrived at that our olfactory nerves are capable of detecting the 1/4,600,000 part of a milligramme of chlorphenol and the 1/460,000,000 part of a milligramme of mercaptan. The quantity of mercaptan present in the air of the room was 250 times less than the amount of sodium present in the air of the room in which Bunsen and Kirchhoff made their experiments upon the sensitiveness of the spectroscope, when the sodium lines were just perceptible.

IN our note last week (p. 64) on Mr. Carey Lee's paper in the *American Journal of Science*, for "protochloride" read "photochloride."

THE additions to the Zoological Society's Gardens during the past week include a Brown Capuchin (*Cebus fatuellus*) from Guiana, presented by Mr. George Doddrell; a Rhesus Monkey (*Macacus rhesus*) from India, presented by Mrs. Livingstone; a Common Marmoset (*Hapale jacchus*) from South America, presented by Mr. J. H. Hallett; a Ring-tailed Coati (*Nasua rufa*) from South America, presented by Mr. Robert R. MacIver; a Brown Bear (*Ursus arctos*) from Russia, presented by Mr. John Rhind; a Grey Ichneumon (*Herpestes griseus*) from India, presented by Mr. J. W. Deacon; a Bare-eyed Cockatoo (*Cacatua gymnopis*) from South Australia, presented by Sir Nathaniel Barnaby; two Daubenton's Curassows (*Crax daubentoni* ♂ ♀) from Venezuela, presented by Mr. F. G. Thompson; two Madagascar Porphyrios (*Porphyrio madagascariensis*) from Mozambique, presented by Capt. J. C. Robinson, s.s. *Roslin Castle*; a Western Slender billed Cockatoo (*Licmetis pastinator*) from West Australia, presented by Miss Streeter; a Horse-shoe Snake (*Zamenis hippocrepis*); an Ocellated Sand Skink (*Seps ocellatus*) from Tripoli, North Africa, presented by Mr. George Russell; two Hawk's-billed Turtles (*Chelone imbricata*) from the East Indies, presented by Mr. J. A. Wilson; a Collared Fruit Bat (*Cynonycteris collaris*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

PHOTOGRAPHY THE SERVANT OF ASTRONOMY.—As an instance of the ease with which relative motions of stars can be detected by the aid of photography may be cited the case to which attention is drawn by M. de Gothard in *Astronomische Nachrichten*, No. 2777. On examining a photograph of the cluster G. C. 4440, taken at the Hérény Observatory in 1886, M. de Gothard found that a small star of the eleventh magnitude had changed its position relatively to the other stars in its neighbourhood by a considerable amount since the date of Herr Vogel's measurements of the relative positions of several of the components of this cluster executed with the Leipzig equatorial in 1867–69. The star in question is No. 48 of Herr Vogel's list, and it appears to have a proper motion of 2″·3 per annum. No. 46 of the same list appears also to have changed its position.

A NEW MINOR PLANET.—No. 266, if, as it would appear, Dr. Luther's discovery of April 11 be really Hesperia, was discovered by Herr Palisa, at Vienna, at midnight on May 17; magnitude 12.

COMET 1887 *e* (BARNARD, 1887 MAY 12).—Dr. E. Lamp supplies the following elements and ephemeris for this object (*Astr. Nach.* No. 2786) from observations obtained at Cambridge, Mass., on May 12, and at Kiel on May 14 and 16:—

$$T = 1887 \text{ June } 18{\cdot}85945 \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \omega &= 17^\circ\ 24'{\cdot}50 \\ \Omega &= 245\ \ \ 8{\cdot}81 \\ \iota &= 17\ \ 31{\cdot}09 \end{aligned}\right\} \text{Mean Eq. } 1887{\cdot}0.$$

$$\log q\ 0{\cdot}13822$$

Ephemeris for Berlin Midnight.

1887.	R.A. h. m. s.	Decl. ° ′	Log *r*.	Log Δ.	Brightness.
May 28	15 39 11	20 20·6 S.	0·1492	9·6024	1·54
30	15 43 19	18 45·8			
June 1	15 47 35	17 8·6	0·1456	9·5919	1·64
3	15 51 56	15 29·8			
5	15 56 22	13 50·1 S.	0·1426	9·5854	1·72

The brightness on May 12 is taken as unity. Dr. Lamp describes the comet as being faint and round on May 14, and as showing a nucleus.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1887 MAY 29–JUNE 4.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 29.

Sun rises, 3h. 53m.; souths, 11h. 57m. 6·9s.; sets, 20h. 1m.; decl. on meridian, 21° 37′ N.: Sidereal Time at Sunset, 12h. 29m.

Moon (at First Quarter on May 30) rises, 10h. 30m.; souths, 17h. 48m.; sets, 0h. 56m.*; decl. on meridian, 11° 40′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Decl. on meridian. ° ′
Mercury	3 55	12 7	20 19	22 49 N.
Venus	6 30	14 54	23 18	24 26 N.
Mars	3 28	11 22	19 16	20 9 N.
Jupiter	15 55	21 13	2 31*	9 3 S.
Saturn	6 53	14 59	23 5	22 2 N.

* Indicates that the setting is that of the following morning.

Occultations of Stars by the Moon (visible at Greenwich).

May.	Star.	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image. ° °
29	45 Leonis	6	20 37	21 34	69 314
29	ρ Leonis	4	23 10	0 2†	88 311
30	σ Leonis	4	19 46	20 6	152 188
June.					
2	94 Virginis	6	20 29	20 39	335 319
4	49 Libræ	5½	19 55	20 30	345 284

† Occurs on the following morning.

May.	h.	
29	2	Mercury at least distance from the Sun.
30	17	Venus in conjunction with and 2° 15′ north of Saturn.
June.	h.	
2	12	Jupiter in conjunction with and 3° 22′ south of the Moon.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·3	81 16 N.	May 29,	1 57	*m*
			June 3,	1 37	*m*
δ Libræ	14 54·9	8 4 S.	,, 4,	2 18	*m*
U Coronæ	15 13·6	32 4 N.	,, 1,	2 6	*m*
W Herculis	16 31·2	37 34 N.	,, 4,		*M*
U Ophiuchi	17 10·8	1 20 N.	May 30,	2 34	*m*
			and at intervals of	20 8	
U Sagittarii	18 25·2	19 12 S.	May 29,	2 0	*m*
			June 1,	1 0	*M*
β Lyræ	18 45·9	33 14 N.	May 31,	23 0	m_2
R Lyræ	18 51·9	43 48 N.	,, 31,		*M*
S Aquilæ	20 6·4	15 17 N.	,, 29,		*m*
δ Cephei	22 25·0	57 50 N.	June 2,	3 0	*M*

M signifies maximum; *m* minimum; m_2 secondary minimum.

Meteor-Showers.

	R.A.		Decl.	
Near β Coronæ	227°	...	30° N.	
	290	...	60 N.	Rather slow.
From Vulpecula ...	303	...	24 N.	Swift.
Near ι Pegasi	333	...	27 N.	Very swift.

GEOGRAPHICAL NOTES.

PROF. GUIDO CORA has constructed a map of the district around Massowah on a scale of 1 : 200,000. He has been able to make use of a variety of original material, and the map will be of use to those interested in the events which are taking place in that region.

THE May number of *Petermann* begins with a short paper on the ethnology of British Columbia, by Dr. Fr. Boas (with map). Dr. H. Polakowsky contributes a paper on the proposed Nicaragua Canal from Greytown to Lake Nicaragua; Paul Emmrich, a paper on the Transvaal gold-fields; and Dr. Rink, on recent Danish exploration in Greenland. Herr Wichmann gives an abstract report of the proceedings of the German Geographentag at Karlsruhe.

THE new number (Band v. Heft 2) of the *Mittheilungen* of the German African Society contains the results of several recent important African expeditions. There is a large-scale map and sections by R. Kiepert, of Böhm and Reichard's journey from Lake Tanganyika to the Lualaba, with remarks by Herr Reichard, observations on altitude, and on the meteorology of the region, by Danckelman. We have also a map of Standinger and Hartert's journey to Kano, Sokoto, and Gandu, with their journals, and remarks on the hypsometrical observations by Danckelman. Prof. Zöppritz contributes a paper on the late Herr Flegel's thermo-barometrical observations on the Niger. There is a letter from Lieut. Tappenbeck on his Congo exploration of 1885, and an analysis of Lieut. Kund's boiling-point observations by Danckelman.

ON ZIRCONS AND OTHER MINERALS CONTAINED IN SAND.

OWING to recent attempts to employ the brilliant light of incandescent zirconia and allied earths instead of that of gas or electricity, attention has been drawn to the sources of the rarer earths.

It occurred to me that an inexhaustible supply might be obtained from the small crystals of zircon so widely distributed in rocks, sands, and soils, if an easy method of concentration could be found. I wished particularly to examine some of the larger deposits of sand, especially the fine-grained deposits, but was stopped by want of the requisite appliances. The matter having been mentioned by a friend to the Director-General of the Geological Survey, I at once received permission to use, for this investigation, the petrological laboratory attached to the Survey. The following results were obtained therein.

The denser minerals were separated from the sand by means of Sonstadt's solution of density 2·86, and borotungstate of cadmium of the density of 3·2.

	Per cent.
Dense minerals in Lower Bagshot sand, Hampstead	3·85
" " another sample	3·60
" " another sample from apparently a different deposit near the Fire-engine Office	1·04
" " High Beeches, Essex	1·32
" Glacial drift sand, Bagillt, North Wales	0·30
" Casting sand, Bullwell, near Nottingham	0·16
" Lower Bagshot sand, near Otterburne, Hants ...	0·12

These heavy minerals were found to be composed principally of matter attracted by a strong magnet, and of zircons, rutiles, tourmalines, and other grains, the relative proportions varying considerably. It will be observed that the richest and the poorest samples were from deposits of the Lower Bagshot sands. The drift sand from North Wales contained, in addition, many garnets. [Since this was written I have received a sample from High Beech Reservoir, 359 feet above Ordnance datum, containing 4 per cent. of dense minerals.]

The sand to which I devoted most attention, and of which I propose to give an account, is represented in the foregoing table by the first two samples. The samples were taken by me from a cutting recently made for the construction of a drain to connect "The Spaniards" and North-End, Hampstead. It was 2 or 3 feet wide, and 10 or 12 feet deep through great part of its length. It passed through a fine-grained yellowish sand, which was thrown out of the cutting or tunneled through in order to lay the drain-pipes. I made an average sample with as much care as though the sand had been a valuable ore which I was sampling for sale or purchase. It represented at least 1000 tons of sand in sight or cut through, and probably many acres of such sand on either side of the cutting. It consisted of grains so small as to pass almost entirely through a piece of cambric, 120 holes per square inch, stretched on a frame and used as a sieve. The average size of the grains was about the two-hundreth of an inch.

By means of dense solutions, vanning, analysis, and the constant use of the microscope, it was found that the sand had the following composition. It is given as an approximation to the truth, and does not, I think, vary more from it than must be expected in cases where it is not possible to get the minerals pure enough for weighing. Only under the microscope could the mixtures and impurities be estimated.

		Per cent.
Quartz, with 1 or 2 per cent. of flint fragments ...	about	75
Feldspar	"	20
Grains attracted by a strong magnet	"	2
Clay	"	1
Zircons in recognisable crystals	"	[illegible]
Grains, more or less opaque, probably zircons	"	[illegible]
Rutiles	"	[illegible]
Tourmalines	"	$\frac{1}{10}$

In addition to the above, there were about 1 per cent. of grains over the density of 3·2, in regard to the composition of which I cannot at present say anything. A few appeared to be cleavage flakes of cyanite, but the majority were opaque earthy-looking bodies of various colours.

Feldspars.—These were nearly all of density equal to or lower than that of quartz. The majority were more or less cloudy, but some were quite transparent, showing the structure of microcline. A few showed the banded structure of plagioclase. Owing to the small size of the particles, and to their cavities and inclosures, I found it impracticable to get a satisfactory separation by dense solutions; and as it was impossible to distinguish the grains in all cases under the microscope, recourse was had to analysis of grains (consisting principally of quartz and feldspar) floated off from the denser minerals in a solution in which quartz floated and anorthite sank. It was found that they contained 94 per cent. of silica and 4·6 of alumina, with an unweighable trace of lime. The alkalies were not determined. This would correspond to about 20 per cent. of feldspar, but the estimate is perhaps rather high, as amongst the matter floated by the solution were found some particles which looked like glauconite covered by a transparent covering of varying thickness; also a little mica and some opaque grains of doubtful origin. It was interesting to note how the small fragments of feldspar have remained unchanged since the parent rocks were formed, and as they survived the disintegration of those rocks so they have continued unchanged in the sands. I saw several containing each a small zircon, and some contained what I think were microliths of apatite. The feldspars were mostly in angular fragments like the quartz.

The zircons are generally transparent and colourless prisms with double terminations of various kinds; many are more or less rounded and some wholly rounded as by attrition.

The rutiles are oblong and rounded grains, but many are sharply edged prisms, and a few have double terminations. Twins are not common, but both knee-shaped and kite-shaped twins occur. These rutiles resemble those of the metamorphic rocks, in which rounded grains and sharply defined crystals are met with side by side.

The tourmalines are generally in flat plates, more or less rounded, but some are perfect crystals with double terminations. They vary much in colour and power of absorption. Various methods of concentrating the zircons were tried. The simplest found was to sift the sand in air or water through a sieve with 120 holes to the inch, that being the smallest mesh I could meet with. In coarse-grained sands, such as the drift sand of North Wales, a considerable enrichment is thereby at once effected, but only a partial enrichment takes place in working with sands so small-grained as to pass entirely through the sieve.

Thus when 8 ounces of the Hampstead sand were sifted till 4 ounces had passed, it was found that the zircons and rutiles, being smaller, smoother, and heavier than the sand, passed

through the sieve faster. By again sifting the 4 ounces which had passed till 2 ounces passed, a further enrichment was found to have taken place. The 2 ounces were again sifted on the same sieve till 1 ounce had passed, which was again sifted till ¼ of an ounce passed. This was examined quantitatively, and found to consist of 54 per cent. of quartz and feldspar, and 46 per cent. of dense minerals. By vanning and submitting the residue to the action of a strong magnet, almost nothing but zircons and rutiles remained. It is needless to say that much remained with the sand, especially in the latter parts of the operation.

A current separater was tried, but it seemed more difficult to work, though perhaps it might answer better on a larger scale, where it might be set to work automatically. There was no difficulty in getting a considerable enrichment, but it was evident that a great deal of care would be required in "sizing" the particles before a good separation could be effected. The most hopeful method seemed to be that of washing away the medium-sized grains of sand and afterwards sifting the sediment.

Perhaps in some of the streams running through the Bagshot or other sands natural eddies may be found or formed artificially from which enriched sand may be dredged, or it may be got on the sea-shore under sand-cliffs.

The object of the present communication is to draw attention to the matter in hopes that some deposit richer in zircons than the Hampstead sand may be found. Much care must be taken in sampling, because the sands, having been deposited from currents, must vary in composition. A trial is easily made by anyone accustomed to use a microscope and who knows the minerals by sight under such circumstances. A thimbleful of such sand as exists at Hampstead is enough for a trial by vanning, but if one of the dense liquids be used, from 10 to 20 grains by weight of the sand will give a good microscopic slide of the dense minerals. It may of course prove that the Hampstead sand is a residue of denudation in which the denser minerals have accumulated. In that case it is not improbable that other similar deposits may be found, some, perhaps, much more zirconiferous.

On the whole it appears that the matter is worthy of further attention. In some future communication I hope to be able to give an account of the composition of the matter attracted by a strong magnet, and also of the grains of earthy-looking minerals over the density of 3·2, and of any richer deposit of zirconiferous sand of which I can obtain reliable samples.

ALLAN B. DICK.

THE ROLLING CONTACT OF BODIES.[1]

WHEN two solid bodies roll upon each other, points in the surface of one successively come into contact with corresponding points in the surface of the other in a way which differs essentially from that which occurs in sliding contact, and it is the nature of this rolling-contact that the lecturer proposed to discuss in an experimental manner.

In the first place, it is well to understand clearly the nature of the relative motion of the two points which come into contact when the surfaces are such that no appreciable distortion of them takes place, and for this purpose one of the two bodies must be at rest. These may respectively be taken as the plane surface of the ground and a circular disk rolling upon it. An approximate representation of this motion is given by the end of the spokes of a wheel without its tyre. In this case it is seen that a point of the rolling body, when it is just coming into contact with the fixed surface, does so in a direction at right angles to the surface at rest, and also leaves it in the same direction. This action is very similar in kind to that which occurs with the continuous circle formed by the tyre. The path of a point in the rim can be drawn in a way visible to the audience by means of a piece of apparatus consisting of two circular glass plates held together by a hollow brass spindle in which slides an arm carrying a brush. The brush traces the well-known cycloid, of which the only portion now to be considered is that where it directly approaches the surface beneath. This part is perpendicular to that surface, and when epicycloids are drawn, by rolling the disk upon the arc of a circle, the same fact is brought out.

One body may, however, not merely roll upon another, and a normal pressure be exerted, but they may exert a tangential force upon each other. It is convenient to keep these two cases separate; examples of them being respectively the wheels of a railway carriage and those of the locomotive which draws it along. It is to be noted that the object in the former case is to permit one body to move relatively to another without permitting sliding contact of their surfaces, whilst, in the latter case, in addition to this, the object is to obtain such motion. There are, however, many cases in which it is merely the motion of a body about one point which is required, such as when motion is transmitted from the edge of one rotating disk to another, and then this distinction still more closely holds, as the normal pressure is only obtained so as to insure the necessary tangential resistance. Thus the objects of rolling motion may be classed as being—

(1) To *allow* the relative motion of one body to another with which it is in contact without permitting relative motion of that part of their surfaces in actual contact.

(2) To *obtain* the relative motion of such parts of the surfaces of bodies as are not in contact by means of statical contact of the parts which are.

The lecturer then proceeded to consider the practical proofs of the smallness of the resistance to rolling in cases where the distortion of the surfaces in contact is very small, as illustrated by the small tractive force required for heavy bodies properly mounted on wheels or on roller-bearings; mentioning the case of a 12-horse-power engine, the shaft of which continued to rotate for three-quarters of an hour after the motive power was withdrawn; and another case, of a turntable weighing 14 tons, which was kept in motion by a weight of 3½ pounds acting upon it by means of a cord passing over a pulley. The small distortion of such surfaces when transmitting motion requiring expenditure of energy to maintain, was next made clear by giving certain facts as to the accuracy with which one surface was developed or measured out upon another. An account was given of experiments made with apparatus specially prepared by the lecturer to investigate this point. This apparatus consisted of two accurately turned brass disks properly mounted upon a frame, and the relative positions of these disks could be interchanged so that any minute differences in their peripheries could be detected. The experiments, which were very difficult to carry out accurately, showed that under the best circumstances, motion with an error of only 1 in 300,000 of the distance passed over could be obtained. This accurate measuring out of the surfaces one upon another was employed in various ways for purposes of measurement, and these, by means of models and diagrams, were briefly explained.

Although the foregoing facts prove that, under suitable conditions, distortion at the points of contact is very small, yet some resistance at these points *always* occurs, because no bodies are perfectly hard; and the nature of this distortion and consequent resistance was next discussed.

The explanation of the resistance opposed by a soft surface to a hard body rolling upon it, as first given by Prof. Osborne Reynolds, was applied by the lecturer to account for a very remarkable effect produced in the disk, globe, and cylinder integrator of Prof. James Thomson. This effect, which was the turning of the cylinder when the sphere was rolled along it in a horizontal direction, was reproduced by means of a large model. The action of a soft body rolling upon a hard surface was next considered, with the result of showing that the same reasoning would not account for the turning of the cylinder in the same direction as before with the above model, and the lecturer then proceeded, by means of diagrams, to offer an explanation of this and other phenomena. The various effects obtained with bodies of different relative degrees of hardness were discussed at length, but figures would be needed to make these points clear. Finally, an explanation was given of the cause of an error which always appeared in a certain important class of integrators caused by the slipping of the edge of a disk over a surface on which it rolled in circumstances under which it had apparently never been suspected that slipping did actually take place. This the lecturer had been enabled to discover and measure by means of a special piece of apparatus, a model of which was exhibited and the effects shown by its means.

The facts and reasoning, which were given in the lecture, all related to the rolling contact of bodies, and the lecturer ventured to think that, imperfect as the treatment of the subject had been, it was one of such importance, not merely from the point of view of the practical applications he had mentioned, but in its scientific aspect, dealing as it did from a novel point of view with the nature and properties of solid bodies, as to be worthy of being thus brought before the Royal Institution.

[1] Abstract of Lecture delivered at the Royal Institution, by Prof. Hele Shaw, on April 29.

A REMARKABLE METEOR.

ON March 17 last, about 4.15 p.m., the track of a brilliant meteor in the southern heavens, at an altitude of 30°, was observed by Mr. R. Brough Smyth, of Sandhurst, Victoria, Australia. Writing to us on March 19, Mr. Smyth says :—

"The line was silver-white and of considerable breadth. The sun was shining in a clear sky. Owing to the view being intercepted by large gum-trees growing in the grounds around my house, I could see only a portion of the arc described. Subsequently, a little after 5 o'clock p.m., the sky was obscured by a kind of mist or vapour at a great height—in colour between steel-grey and lead-grey, and with tints similar to those of the metal bismuth over the whole. All objects looked green or greenish in the strange light. The meteor was observed at Salisbury in South Australia, at Coleraine in the extreme west of Victoria, and at various places eastward—say over a distance of 400 miles. It travelled apparently from east to west, and as far as known was visible in the southern part of Australia only. In some places it presented the appearance of a blood-red ball, and at Beaufort the ball is said to have exploded with a loud report, sending up a streak of fire, accompanied with the hissing of escaping steam, as from an engine. It left a cloud of greyish smoke. This smoke-like cloud was observed in other places. At Warrnambool on the west coast, and at Terang, twenty-five miles north-eastward, shocks of what were supposed to be earthquakes were felt at the time of the disappearance of the meteor. Cattle and horses galloped about in alarm, houses were shaken, windows rattled, and the wild fowl in the lakes were disturbed, and took wing. I inclose cuttings from the *Argus* containing accounts of this phenomenon."

The "cuttings" inclosed by Mr. Smyth are a series of telegrams, describing the phenomenon as seen in various parts of Australia. At Coleraine, "a brilliant ball of fire shot from the zenith in a clear sky to 30° above the horizon, and then disappeared as it exploded, leaving a large cloud of white smoke, which was visible for half an hour. Exactly six minutes subsequently, two distinct shocks like cannon reports were heard, with a perceptible tremor of the atmosphere. The phenomenon was witnessed by 500 persons." At Merino, "a most unusual phenomenon appeared in the eastern sky. A streak like smoke from a volcano appeared. Immediately after the appearance, a report like distant thunder was heard from the same direction. It was thought that an aërolite of immense size had fallen between Merino and Hamilton." At Stawell the "meteor appeared to burst just beyond the town in a cloud of smoke, which was immediately followed by a loud crash like thunder." From Terang it is reported that at Lake Keilambete "the black swans were noticed to rise suddenly off the lake. A rumbling noise appeared to pass under, causing the cattle grazing on the banks of the lake to scamper away, and on gaining some distance they were seen to look back. The noise was heard in other places, and seemed to pass to the south-west." At Portland, "three distinct reverberations like the booming of artillery were heard about 4 p.m." The people at Warrnambool, hearing, shortly after 4 o'clock, loud detonations like a volley of musketry, with subsequent dropping shots, rushed out of their houses; and "the cattle were paralyzed with fear at the sounds." The disappearance of the meteor over Beaufort, where it is said to have exploded, "was followed by earth tremors and a rumbling sound as of the firing of heavy artillery. The vibrations lasted for ten seconds. Several houses were shaken severely. No substance appears to have fallen to the earth."

SCIENTIFIC SERIALS.

THE contents of vol. lv. part 2, No. 4, of the *Journal of the Asiatic Society of Bengal*, are varied. They commence by a memoir on the land shells of Perak, by Dr. O. F. v. Möllendorff, in which 58 species (many new) are enumerated or described. Then follows an account of solar thermometric observations at Allahabad, by S. A. Hill, Meteorological Reporter to the Government of the North-West Provinces. The third memoir is an historico-geographical study on probable changes in the Punjab and its rivers, by R. D. Oldham, of the Indian Geological Survey, a paper on which much research has been expended, tending to prove that a second large river, independent of the Indus, once existed in the Punjab, and that the geological changes which converted a once fertile district into a desert probably date so recently as the early centuries of the Christian era. The next is a very important entomological investigation of the butterflies of Cachar, by Prof. Wood-Mason and Mr. L. De Nicéville, enumerating no less than 247 species obtained between the end of March and the beginning of October. A remarkable feature is the large number of *Hesperiidæ*, of which 53 distinct species were obtained. There are valuable notes on seasonal and local variation, and a considerable number of new species are described, and mostly figured on four plates, one of which is a chromo-lithograph executed in London, the others "autotype," and apparently very successful examples of what may be produced by the process as applied to natural history subjects. Dr. King follows with a short paper on some new species of *Ficus* from New Guinea, in which the author largely quotes from and anticipates a monograph on Indo-Malayan and Chinese figs prepared for the Linnean Society; the remarks are worthy of very careful study, and open up much new light on the somewhat obscure subject known as "caprification." The concluding paper is a very short one by Mr. J. S. Baly on a new species of *Hispa* destructive to the "dahn" crops in Chittagong. On the whole this part is one of the most valuable that have been issued by this long-established Society.

Proceedings of the Linnean Society of New South Wales, 2nd series, vol. i., part 4, February 22, 1887 (Sydney), contains :—*Zoology:* George Masters, catalogue of the described Coleoptera of Australia, part 6.—E. Meyrick, descriptions of new Lepidoptera. A large number of new species and several new genera are described; a new species of Thalpochares is given the name of Coccophaga, from the singular habits of the larva, which feeds solely on a Coccus infesting a Macrozamia.—E. P. Ramsay, notes on the eggs of various Australian birds; list of Western Australian birds collected at Derby; on the nest of *Pycnoptilus floccosus* (plate xx.); on a new species of Hapalotis (*H. boweri*) (plate xviii.).—E. P. Ramsay and J. Douglas-Ogilby, on a new species of Apogon (*A. roseigaster*).—William Macleay, on a new species of Hoplocephalus (*H. collaris*).—C. W. De Vis, on new or rare vertebrates from the Herbert River; describes a new Pseudochirus (*P. mongan*), a new Dromicia (*D. frontalis*), and records the occurrence of some rare species.—A. J. North, notes on the bower birds, and some references to authentic descriptions of Australian birds' eggs.—*Botany :* E. Haviland, flowering seasons of Australian plants.—J. Stirling, on the Rutaceæ of the Australian Alps.—Baron von Mueller, on some hitherto undescribed plants of New South Wales. *Grevillea renwickiana* is described as quite procumbent, with elongated branches, being in this respect like *G. laurifolia* and *G. repens*, but differing from both in the larger and much less numerous flowers; also new species of Melaleuca, Bossiæa, and Pultenæa.—*Palæontological:* F. Ratte, notes on Australian fossils.—W. J. Stephens, on some new Labyrinthodonts (plates xiv. and xxii.).—J. Mitchell, on the geology of Bowning, N.S.W.

Zeitschrift für wissenschaftliche Zoologie, vol. lv. Part 2, April 13, 1887, contains:—Dr. O. Schultze, researches on the ripening and the fertilization of the amphibian ova, part 1 (plates xi. to xiii.).—Dr. Wilhelm Roux, on a fungus living parasitically in bones (*Mycelites ossifragus*) (plate xiv.). The author gives an account of the filaments of this fungus occurring in the bones of a large number of extinct forms of mammals, reptiles, and fishes.—Dr. Otto Zacharias, contributions to the pelagic and littoral fauna of the German Ocean. In this paper are described a large number of Entomostraca, Rotatoria, Hydrachnida, and Turbellaria, some new. In an appendix, S. A. Poppe describes a new species of Temorella from Holstein and Mecklenburg (plate xv.).—Dr. H. Strahl, on the walls of the yolk-sac and on the parablast in lizards (plate xvi.).—Dr. Joseph Heinrich List, on the glandular structures in the foot of *Tethys fimbriata*, L. (plate xvii.). These glands are found both on the upper and under side of the feet, and are of four different sorts; while some are slime organs, others may be phosphorescent organs.—Dr. Eugen Korschelt, on some interesting phenomena in the formation of the eggs of insects (plates xviii., xix.).

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 28.—"On the Homologies and Succession of the Teeth in the Dasyuridæ, with an Attempt to

trace the History of the Evolution of Mammalian Teeth in general." By Oldfield Thomas, British Museum (Natural History). Communicated by Dr. Albert Günther, F.R.S.

The true homologies of the different teeth in the Marsupialia, and especially in the *Dasyuridæ*, have long been in a state of confusion, a confusion that has been chiefly in regard to the premolars, of which some members of the family have two, others three, while generalized Placentals have four, and it is therefore necessary to prove which teeth have been successively lost in order to find out the correct homologies of the remainder.

Firstly, as to which of the three premolars of ordinary Marsupialia has been lost in *Dasyurus*, with only two, it is shown that it is the last premolar, or pm.^{4}, that is missing in this genus.

Next, it was necessary to find out which of the original four premolars had disappeared in the ordinary three-toothed genera of the Polyprotodonts, and this has been able to be done by the fortunate discovery of a specimen of *Phascologale* in which there are four premolars on one side, the additional tooth being inserted behind the first premolar. The missing premolar is therefore pm.^{2}, the resulting premolar formula of *Phascologale* and *Thylacinus* being P.M. $\frac{1 . 0 . 3 . 4}{1 . 0 . 3 . 4}$ and of *Dasyurus* P.M. $\frac{1 . 0 . 3 . 0}{1 . 0 . 3 . 0}$.

The milk dentition in several of the *Dasyuridæ* is then described, and also that of the Mesozoic *Triacanthodon serrula* (Owen), which is definitely proved to have a true Marsupial milk dentition.

An attempt is then made to trace out the history of the evolution of mammalian teeth in general, and it is suggested that the process by which a milk tooth was developed consisted of two stages, firstly, a preliminary retardation of the permanent tooth, and secondly, of the development of a temporary tooth in the gap in the tooth-row caused thereby; the retardation in the first case being useful for packing purposes in a large-toothed animal, while in a small-toothed form the same retardation, if present by inheritance, would cause a more or less disadvantageous gap, best filled by the assumption of a milk tooth.

Following out this idea, it is shown how easily the transition from the Metatherian to the Eutherian state of tooth-change may have taken place, a transition by the help of which a complete series of diagrams can be drawn up, following the history of each individual tooth, from the dentition of the earliest mammals, homodont and monophyodont, down to the varied forms of dentition, heterodont and diphyodont, existing at the present day.

For the Edentates alone it is necessary to draw up a special branch of tooth development arising directly from the Prototheria, a branch for which the name of "Paratherian" is proposed.

Physical Society, May 14.—Prof. W. E. Ayrton, Vice-President, in the chair.—Mr. T. Mather was elected a member of the Society.—The following papers were read:—On a modification of a method of Maxwell's for measuring the coefficient of self-induction, by Mr. E. C. Rimington. The method referred to is given in Maxwell's "Electricity and Magnetism," § 778, vol. ii., and is called "comparison of the electro-static capacity of a condenser with the electro-magnetic capacity of a coil." The apparatus used consists of a Wheatstone's bridge having the coil in one, and the condenser as a shunt to the opposite, arm. In order that no deflection may be produced, either for steady or unsteady currents, a troublesome double adjustment of the resistances is necessary, and to obviate this the modification was devised. It consists in placing the condenser as a shunt to only part of the arm, and this part can be varied by sliding contacts without altering the whole resistance of the arm. An ordinary resistance balance for steady currents is first obtained, and the sliders are then adjusted until no deflection is produced on breaking the battery circuit. Under these circumstances it is shown that $L = Kr^2\frac{D}{B}$, where K is the capacity of the condenser, r the resistance between the sliders, and D and B the resistances of the arms in which the coil and condenser are placed. The conditions of maximum sensibility are investigated, and also those under which a telephone may replace the galvanometer; in the latter it is shown that the only possible solution is when $r = B$, *i.e.* Maxwell's arrangement. The author believes his modification would be made much more sensitive by adopting the "cumulative" method used by Profs. Ayrton and Perry in their secohmmeter; and in his case neither the speed nor the "lead" need be known. Mr. W. N. Shaw asked whether any serious difficulties were experienced with telephones, owing to electro-static capacities of wires, &c., and Mr. W. E. Sumpner pointed out that the particular arrangement given in Maxwell is not always the most sensitive, as was shown in his remarks at the last meeting of the Society of Telegraph-Engineers. Mr. Bosanquet thought the method a valuable one, and hoped many experiments would be made on coils whose coefficients were calculable, in order to find out the differences between calculated and observed results. Prof. Ayrton referred to the paper by Prof. J. J. Thomson in the Philosophical Transactions, and pointed out that the formula there given for the capacity of a condenser in electro-magnetic measure, is identical with that given in Maxwell, § 776, when the printer's error of interchanging a and α in the denominator for R_2 is corrected.—On the production of sudden changes in the torsion of a wire by change of temperature, by Mr. R. H. M. Bosanquet. A very fine hard-drawn platinum wire, four or five feet long, was used as a suspension for a ballistic galvanometer, and exhibited peculiar phenomena. The steel needles were replaced by brass ones, and the peculiarities investigated. When the room was warmed, the needles swung round nearly 70° for a few degrees rise of temperature, and remained in about the same position for further rises. If it was now cooled a few degrees (3° or 4° F.), they quickly returned to their initial position. The author has not found a complete explanation, but believes it to be due to unequal expansion, and loose contact amongst molecules, and has devised a simple mechanism to illustrate his meaning. Remarks and suggestions were made by Prof. Perry, Mr. Lant Carpenter, and the Chairman.—On a magnetic potentiometer, by Mr. A. P. Chattock, read by Prof. Reinold. The "so-called" magnetic resistance between two points on a magnetic circuit may be expressed as the ratio of the difference of potential to the total induction passing from one to the other (provided there be no magnetomotive force between them). From the fact that the volume integral of induction through a wire helix of constant cross-section is proportional to the average difference of potential between its ends, it follows that any alteration in that difference of potential will give rise to an E.M.F. in the helix proportional to that alteration. Hence, if the wire be connected to a ballistic galvanometer, the combination may be called a magnetic potentiometer. A helix is formed by winding wire uniformly on a piece of solid india-rubber, or canvas gas-tubing, of constant cross-section, using an even number of layers to avoid external inductive effects, and leaving a small space between the turns so as to allow the tube to bend without elongating. Experiments made to measure the difference of potential between the ends of a magnet gave satisfactory results. One end of the helix was held stationary at one end of the magnet, whilst the other was moved quickly to the other end of the magnet, and the resulting throw of the galvanometer observed. This was next done at two operations, and the sum of the two throws was very nearly equal to the first. The results can be reduced to absolute measure by passing the helix through a coil of n turns, bringing its ends together, and starting or stopping a current, C, in the coil, the resulting throw of the galvanometer being noticed. The magnetomotive force used in this experiment is $4\pi n$C. An interesting discussion followed, in which Prof. Perry, Mr. Shaw, Prof. Ayrton, and Mr. Bosanquet took part, the latter mentioning a measurement of magnetic potential made by himself some years ago.—In consequence of the absence of Prof. S. P. Thompson, his paper on secondary generators was postponed till next meeting.

Geological Society, May 11.—Prof. J. W. Judd, F.R.S., President, in the chair.—The following communications were read:—Further observations on *Hyperodapedon gordoni*, by Prof. T. H. Huxley, F.R.S. The author briefly noticed the circumstances under which he first described the occurrence of Lacertilian and Crocodilian fossils in the Elgin sandstones, and the confirmation which his views as to the Mesozoic age of these remains had received from the discovery of *Hyperodapedon* in English Triassic rocks and in India. The original type of *Hyperodapedon gordoni* from Elgin was, however, in bad condition, and the receipt at the British Museum of a second much better preserved skeleton, found in the Lossiemouth quarries of the same neighbourhood, had enabled him to add considerably to the known characters of the genus, and to compare it more thoroughly both with the recent *Sphenodon* (or *Hatteria*) of New Zealand and with the Triassic *Rhynchosaurus articeps*, several

specimens of which are in the British Museum palæontological collection. The recently discovered *Hyperodapedon* skeleton was of nearly the same size as that formerly described, and must have belonged to an individual about 6 or 7 feet in length. The specimen was exposed by the splitting of a large block of sandstone, and comprised the skull, the vertebral column as far as the root of the tail, all the bones of the left and of part of the right fore-limb, and those of the right hind-limb, the whole almost in their original relations. The bones were described in order and compared with those of *Sphenodon*, the most important differences in *Hyperodapedon* being the following:—(1) The centre of the presacral vertebræ are ossified throughout and more or less opisthocœlous, especially in the cervical region. (2) The anterior cervical vertebræ have long and strong ribs. (3) The external nares are not separated by bone. (4) Conjoined premaxillary bones form a long, conical, curved, pointed rostrum, which is received between the rostral processes of the mandible. All these were devoid of teeth and probably sheathed in horn. (5) The palatal area is very narrow in front and wide behind, with strongly curved lateral boundaries. (6) The posterior maxillary and palatal teeth are multiserial. (7) The rami of the mandible are united in a long symphysis, behind which they diverge widely, and the dentigerous edges are strongly concave upwards as well as outwards. (8) The mandibular teeth in front are set into a close, apparently continuous palisade, and become distinct and conical only at the posterior end of the series. (9) The fore-foot is remarkably short and stout, with metacarpals of equal length. The relations of *Rhynchosaurus* to *Hyperodapedon* and *Sphenodon* were then dealt with, the first-named being shown to occupy in some respects an intermediate place between the two others. The skull of *Rhynchosaurus* resembles that of *Hyperodapedon* in its single anterior nasal aperture, its premaxillary and mandibular rostral processes, and in having more than one series of palatal teeth; but in general form and in the shape of the maxillæ, palatal bones, and rami of the mandible it departs far less from *Sphenodon* than *Hyperodapedon* does. Some comparisons of the limb-bones were also made. The three genera mentioned were shown to form a particular group, which, however, had no claim to ordinal distinction, and appeared to form a family, Sphenodontidæ, of the Lacertilia, comprising two sub-families, Rhynchosaurinæ (including *Rhynchosaurus* and *Hyperodapedon*) and Sphenodontinæ. The fact that in this Lacertilian group the highest known degree of specialization, as shown in *Hyperodapedon*, was attained as early as the Triassic epoch, showed that in Permian times, or earlier, Lacertilia existed which differed less from *Sphenodon* than either of the Rhynchosaurinæ did. Not only was the Lacertilian type of organization clearly defined in the Triassic epoch, but it attained a degree of specialization equal to that exhibited by any modern lizard. The reading of this paper was followed by a discussion, in which the President, Dr. Geikie, Prof. Seeley, Mr. Lydekker, Prof. Boyd Dawkins, and others took part.—On the rocks of the Essex drift, by Rev. A. W. Rowe.—On Tertiary Cyclostomatous Bryozoa from New Zealand, by Mr. Arthur W. Waters.

EDINBURGH.

Royal Society, April 18.—Sir W. Thomson, President, in the chair.—Prof. Rowland's photographs of the solar spectrum were exhibited.—The President read a paper on ship-waves, and another on the instability of fluid motion. Both papers appear in the *Phil. Mag.*—Mr. D. S. Sinclair gave a communication on an experimental research in magnetism.—A paper by Mr. A. H. Anglin on the summation of certain series of alternants was submitted.—Prof. Crum Brown read a paper by Mr. H. Marshall on cobaltic alums.—Mr. G. N. Stewart submitted a synopsis of researches on the effect produced on the polarization of nerve by stimulation.

May 2.—Sir Douglas Maclagan, Vice-President, in the chair.—Prof. J. B. Haycraft read the third part (on the sense of smell) of a paper on the objective cause of sensation.—Prof. Crum Brown read a paper on the physics of noise. His object is to investigate the various components which make up ordinary noises, such as a hissing sound.—Prof. Dittmar and Mr. C. A. Fawsitt communicated a paper on the physical properties of methyl alcohol.—Prof. Dittmar also discussed the instability of the double salts of $M''SO_4 . R'_2SO_4 + 6H_2O$ of the magnesium series.—Mr. J. Rattray described a diatomaceous deposit found at North Tolsta, Lewis.

PARIS.

Academy of Sciences, May 16.—M. Janssen in the chair.—Obituary notices of the late M. Boussingault, member of the Section for Rural Economy, who died on May 11, by MM. Schlœsing, Troost, and the President.—On some deviations from the normal direction of sound calculated to render ineffective the fog-signals and similar appliances employed in navigation, by M. H. Fizeau. The paper, written with reference to some recent shipping disasters during foul weather, shows on theoretical grounds that, the surface of the sea being at times warmer than the surrounding atmosphere, the aërial strata must in calm weather decrease in temperature upwards to a certain height above sea-level. This occurs not only at night, but also frequently during the day in foggy weather. Hence the sounds of the fog-signals, intended to be propagated horizontally, are necessarily affected by the differences of atmospheric temperature, those nearest the surface of the water acquiring greater velocity than those traversing the higher strata. Thus is at times produced a sort of "sound mirage," perfectly analogous to the well known corresponding phenomena of light. Once the cause of the deviations is understood, the means of counteracting them will easily suggest themselves.—Effects of earthquakes on magnetic instruments, by M. Mascart. The reports of magnetic disturbances received from various stations in France, England, Germany, Russia, and other European countries, show great discrepancies as to the time and intensity of the shocks; but whether these discrepancies are to be attributed to possible errors of observation, to the difference in the character of the instruments, or to physical causes, cannot at present be determined. If the cause of the disturbances is really electric, its very mechanism is absolutely unknown.—Observations of Barnard's new comet, *e* 1887, made at the Paris Observatory (equatorial of the West Tower), by M. G. Bigourdan. This comet, discovered on May 12, at Cambridge, in the United States, was seen at Paris on May 14, when it presented the appearance of a round nebulosity of 1′ diameter, and of the thirteenth magnitude, with considerable central condensation, notwithstanding its slight altitude above the horizon.—On the direct determination of the differential coefficient $\frac{dp}{dt}$, relative to saturated vapours, by M. A. Perot. It is shown that the mechanical equivalent of heat may be determined by the well-known relation—

$$L = \frac{1}{E} T (u' - u) \frac{dp}{dt},$$

which is obtained by applying to a liquid mixture and its vapour the principle of equivalence, and that of Carnot. In order to approximately determine this quantity, the author has undertaken to measure on the same sample of pure ether, at a temperature of 30°, the different parameters entering into the preceding relation—u', u, L, and $\frac{dp}{dt}$. To determine $\frac{dp}{dt}$ he employs a special method, which enables him to measure separately the two corresponding quantities dp and dt. The determinations have been made for the temperatures 29° to 31° inclusive, within which interval they may be represented by the formula—

$$\frac{dp}{dt} = 2{\cdot}2750 + (t - 29)\, 0{\cdot}0834.$$

—Intertropical diurnal and annual variations of terrestrial magnetism (second note), by M. Ch. Lagrange. By comparing the observations recorded at two stations on either side of and equidistant from the equator, such as Bombay and St. Helena, Hobartown and Toronto, the author finds that there exists in the atmosphere and in the earth a system of currents moving east and west, whose strata of greatest intensity penetrate the atmosphere, descending in the hot season below the surface of the earth and again rising in the cold season. This system seems to prove the reality of Ampère's general system of currents extended to the earth and the atmosphere. From this it also follows that the existence of these aërial magnetic currents involves a diminution of temperature with elevation. Consequently these currents are one of the factors, possibly the chief factor, in the thermic system of the globe, so that a fundamental connexion exists between meteorological phenomena and those of terrestrial magnetism.—On the reproduction of alabandine, by M. H. Baubigny. By the process here described the author has obtained some beautiful octahedric crystals, presenting all the characteristics of alabandine (MnS): the same crystalline form, colour, and

density, about 4.—Contribution to the study of the alkaloids, by M. Oechsner de Coninck. Having in a previous paper described the reaction of potassa on a combination of the iodide of ethyl with nicotine, the author here confirms by a fresh line of observation the relation of nicotine to the pyridic and dipyridic series.—On some fossil woods found in the Quaternary formations of the Paris basin, by M. Emile Rivière. These specimens were found associated with the animal remains already frequently described by the author. A microscopic study has enabled him to determine three different vegetable species: Palm, Cedroxylon, and Taxodium. The last-mentioned was especially abundant in the Miocene epoch, and appears to be older than the non-fossilized specimens from time to time discovered in the boggy districts of Switzerland.

BERLIN.

Physical Society, April 22.—Prof. Du Bois-Reymond, President, in the chair.—Dr. Gross explained his theoretical views on the heat of solution of magnetised iron, and showed why, in accordance with these, the heat of solution of magnetised iron must be greater than that of unmagnetised. One result of these views was that a piece of magnetised and unmagnetised iron in a conducting fluid capable of dissolving the iron must give a current; this he has already demonstrated two years ago (see NATURE, vol. xxxi. p. 596). The current in such an element as this flows across the fluid from the magnetised to the unmagnetised pole, and is independent of the nature of the magnetisation. The source of the electric current is in this case, according to the views of the speaker, to be sought for in the loss of specific magnetisation which the molecules of iron undergo as they pass from the solid to the fluid condition. Of the various solutions of salts of iron which were used in these experiments, only neutral salts of ferric oxide were found to yield a result, while the salts of ferrous oxide gave no current. The cause of this is, according to the speaker, that only the ferric salts lead to a solution of the magnets. Dr. Nichols has quite recently carried on some experiments on the heat of solution of magnetised iron, and has obtained the same experimental results, namely that the heat of solution of magnetised iron is greater than that of unmagnetised, although he starts with theoretical views respecting the magnetic potential of solid iron and iron in solution which are diametrically opposed to those of Dr. Gross.—The President exhibited a Bourdon's manometer, and explained its use for the measurement of alterations of blood-pressure in living animals. In connexion with this the President gave a full account of the physical portions of the research which Dr. Grunmach has carried out on the influence of elasticity on the rate of progression of the pulse-wave. The most important points of this research have already been communicated in the report of the last meeting of the Physiological Society on April 15 (NATURE, May 12, p. 48).

Physiological Society, April 29.—Prof. Du Bois-Reymond, President, in the chair.—Dr. Onodi, of Buda-Pesth, gave an account of the anatomical investigations which he carried on during his two visits to the Zoological Station at Naples. In the first place he busied himself with the anatomy of the ciliary ganglion, which he examined microscopically in twenty-five different species of Selachians. From what he found in these lower vertebrates, as well as from observations which he had an opportunity of making on the embryos of cartilaginous fishes and chicks, he has come to the conclusion that the ciliary ganglion must be reckoned in with the sympathetic plexus. In addition to the above researches Dr. Onodi was occupied with investigations on the roots of the vagus, and he communicated a number of interesting details on their relations in the Selachians.—Dr. König spoke on Newton's law of colour-mixing, explaining its principle, and illustrating it with the aid of a Newton's colour-chart. He then developed the three propositions which Grassmann has deduced from the Newtonian law, and which, as is well known, are as follows: (1) when two spectral colours are mixed the resulting compound colour is a spectral colour lying between the other two, but mixed with white; (2) when one of the two colours which is being mixed is continuously changing, then the resulting compound colour also changes continuously; (3) similar colours when mixed give similar compound colours. Of these three propositions the first has not been confirmed by later experimental researches, but this does not diminish the value of Newton's law of the mixing of colours: it only becomes necessary to substitute a triangular colour-chart for the circular one put forward by Newton. The second proposition was fully confirmed by experience. The third proposition, which may also be expressed by saying that the compound colour is independent of the intensity of its separate constituents, was not confirmed by experiments. The speaker has alone, and in conjunction with Herr Breduhn, carried out careful measurements on trichromatic and dichromatic eyes, and has always observed a difference in the compound colour as the result of marked differences in intensity of the compounded colours. The validity of Newton's principle in its general form is therefore considerably shaken by this discovery, and must be confined to narrow limits of variations of intensity.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Agricultural Pests of India: Surgeon-General E. Balfour (Quaritch).—Schriften der Naturforschenden Gesellschaft in Danzig (Danzig).—The Storage of Electrical Energy: G. Planté (Whittaker).—Manual of Bacteriology: E. M. Crookshank (Lewis).—Chance and Luck: R. A. Proctor (Longmans).—Manual of Scientific Inquiry, 5th edition: edited by Sir R. S. Ball (Eyre and Spottiswoode).—Elementary Trigonometry: Rev. T. Roach (Clarendon Press, Oxford).—Our Bird Allies: T. Wood (S.P.C.K.).—Dandelion Clocks: J. H. Ewing (S.P.C.K.).—Agriculture in some of its Relations with Chemistry, 2 vols.: F. H. Storer (Low).—The Fungus-Hunter's Guide: W. D. Hay (Sonnenschein).—Forestry of West Africa: A. Moloney (Low).—Shores and Alps of Alaska: H. W. Skarr (Low).—The Races of the British Isles (Quaritch).—Rousdon Observatory, vol. iii., Meteorological Observations for the Year 1886: C. E. Peek.—Transactions of the Seismological Society, vol. x. (Yokohama).—New Commercial Plants and Drugs, No. 10: T. Christy.—Quarterly Journal of the Geological Society, vol. xliii., part 2, No. 170 (Longmans).—Bulletin of the American Geographical Society, 1886, No. 3 (New York).

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